VOLUME 59 [W. B. No. 1062] NUMBER 11

MONTHLY WEATHER REVIEW

NOVEMBER, 1931

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MONTHLY WEATHER REVIEW

Editor, W. J. HUMPHREYS

VOL. 59, No. 11
W. B. No. 1062

NOVEMBER, 1931

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INFLUENCES OF LAKE MICHIGAN ON EAST AND WEST SHORE CLIMATES[1]

By CLARENCE BURT ODELL

[Geography Department, University of Nebraska, Lincoln, Nebr., November, 1931]

The influence of Lake Michigan upon the climate of the eastern shore in making it a region favorable to fruit growing is generally understood. However, little in the way of quantitative proof in the form of graphs from weather reports has been attempted. In view of the fact that there is general knowledge pertaining to the differences in climate upon the opposite shores of the lake it has been considered of enough importance to take averages of 15 years of weather reports for stations situated on the east and west shores, in approximately the same latitudes, and to put these results into graphic form. The stations of Milwaukee and Grand Haven were used as one pair and the stations at Green Bay and Ludington as another; thus, the matter of latitude need not be considered, since these pairs are located near the same parallels.

The climatic factors used in the graphs were temperature, wind velocity, number of clear days and cloudy days, precipitation, and the number of days with snow. The number of times that the minimum temperature fell below certain critical points was counted and used in three graphs in order to show which side of the lake is more favorable to fruit culture as far as temperatures are concerned. The critical temperatures for peaches were used, and the estimated damaging temperatures were obtained through consultation with the pomology department of the University of Illinois. A long discussion of each of the graphs and of the why's and wherefore's is not necessary because a study of the figures will bring out very clearly the striking influence of this body of water. Somewhat similar differences are noted between east and west shores at both pairs of stations and these differences in climate may be assigned to the influences of the lake in spite of its relatively small size.

TEMPERATURE

There seems to be a greater range of temperature at the west shore stations—Green Bay and Milwaukee—than at the eastern. (Figs. 5 and 6.) The range, however, is naturally greater at the two northern stations. Grand Haven and Ludington are warmer in the winter and cooler in the summer than Milwaukee and Green Bay. This is due to the winds coming over the water which is cooler than the land in the summer and warmer for the most part in the winter, a result of the difference in the rate of heating and cooling of land and water. There is also a slightly more rapid increase of temperature in the spring and decrease in the fall at Milwaukee and Green Bay than on the eastern shore, due, probably, to the same reason.

The temperature is more nearly uniform at Ludington during July and August than at Green Bay, another apparent water influence. The prevailing wind is south for the two stations during both months.

An attempt also has been made to show how favorable the temperatures are to grow good peach crops on the Michigan and Wisconsin shores of Lake Michigan. Data were taken from the CLIMATOLOGICAL DATA and the following figures were used as the minimum critical temperatures[2] (° F.) which would damage the fruit:

	°F.
January	−15
February	−10
March	5
April	15
May	28

In each of these months for 15 years (1914–1928 inclusive) the number of times was recorded in which the temperature fell below these critical points and the totals were compared. The graphs show the results and it can be seen that Ludington and Grand Haven had fewer killing temperatures and also had more years that were entirely free from damaging temperatures than Green Bay and Milwaukee stations. It does not necessarily follow, however, that the years recorded without such temperatures had good peach crops. Many other factors enter into the production of the fruit—likewise with the other crops grown. Some of these items are wind, rain, soil temperatures, temperatures during the preceding fall and winter, amount of snow covering, amount of sunshine, and humidity. The exposure of the orchard and its drainage, both soil and air, will greatly affect the setting of the fruit. However, the temperature conditions are of fundamental importance to growth, insect flight, rainfall, and humidity.

Figure 1 shows that Green Bay had killing or damaging temperatures in 14 out of the 15 years; Ludington, only 7; Milwaukee, 11 out of the 15; and Grand Haven, only 9. Thus the chances for a damaged crop from too low a temperature are approximately 30 per cent greater on the west shore than on the east. Also the total number of times that the temperatures fell below the critical temperatures were much greater in Green Bay and Milwaukee than at the east shore stations. Here, then, is one important reason why peaches may be grown on the Michigan shore and not on the Wisconsin shore.

However, it must not be assumed that there are no peach crops except in the years entirely free from damaging temperatures. In many of the years when the mercury fell only once or twice below the critical temperature

[1] The weather data used were obtained from the annual reports of the chief of the United States Weather Bureau for the 15-year period of 1914–1928, inclusive. The data used in the section on critical temperatures were obtained from the monthly and daily records found in the Climatological Data (1914–1928, inclusive) for the months of January through May. The Michigan Department of Agriculture furnished data for the actual crop condition or production percentages.

[2] Figures by Dr. J. M. Dorsey, professor of pomology, University of Illinois, Urbana, Ill.

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it would not necessarily damage the whole crop. Perhaps just one section of an orchard or even parts of the trees might be damaged and the rest unhurt. The temperatures as given in the records are for the immediate vicinity of the Weather Bureau station and it is entirely possible that that reading might be found only in the station's instrument shelter. Even in the same orchard, or perhaps on the same tree, air drainage might cause a section to be damaged and the rest to be unharmed. Also, there are so many factors influencing the setting of the fruit that it must not be assumed that there was a perfect peach crop every year in which no damaging temperatures were recorded any more than that the entire crop was destroyed in the years with critical temperatures.

Of course the killing temperatures are different for various fruits but the peach is rather sensitive to low temperatures so that this study may be applied to all fruits grown in the region with some degree of accuracy. The Michigan peach regions center about Ludington and Grand Haven. Hence, the data here used are fairly representative of the conditions in the orchards. Peaches are not grown near Green Bay or Milwaukee and the data obtained from those stations show why that industry would not be profitable there.

Figure 2 (sections A, B, C, D) shows the number of times the temperature fell below the critical point each month for each of the stations. The month of March seems to be the one with the greatest number of times with damaging temperatures. The damage done by the cold in March will depend upon the weather in the preceding months and upon the growth of the tree at the time of the low temperature.

The two graphs (figs. 5 and 6) giving the average temperatures for the four stations show that spring is retarded on the east shore; therefore the trees should not be so far advanced as on the west shore, and hence, a low temperature would not do so much damage to the trees near Ludington and Grand Haven, as on the west coast.

In Figure 3, annual occurrence of critical temperatures, the figures on the right are the number of years during the 15 in which there were the same number of temperature drops below the critical points. This will indicate to a certain degree just how severe the temperatures were for the various years, and also how different the conditions are at the four stations. Thus, in Green Bay we find that in three different years damaging temperatures were recorded fifteen times and that but one year was entirely free. Milwaukee had three with five or more times below the killing point. Ludington had seven years entirely free with but one year as high as five times. Grand Haven had six free years and only two years as many as four times below the damaging point. This all indicates greater freedom from this great danger in western Michigan and the advantage of this section as a peach region over the eastern portion of Wisconsin.

Figure 4 showing the final condition, or production percentages, show some correlation with the last-mentioned one. When the number of occurrences of the critical temperatures goes down, the percentage of production goes up, and vice versa. A few exceptions may be noted, as in 1921, but they may possibly be explained by the other climatic factors. In 1921, however, according to the CLIMATOLOGICAL DATA for January to July, the reports indicate that there was an unusually mild winter. January, February, and March were mild and above normal, but April came in with a cold wave and also had blizzards in the middle of the month over the lower peninsula. Cherries, peaches, plums, apples, strawberries, and garden truck were badly frozen. The report also states that a cold wave came the 15th and 16th of May and that there was some damage since the vegetation was two weeks in advance of the normal season. In this case temperatures might not have been low enough to do harm in ordinary circumstances but due to the advanced season the buds were damaged at a temperature higher than 15° in April and 28° in May. It must be realized that these critical temperatures are only estimates and are used only as a basis for the study. Many variations of temperatures are possible whereby damage will be done to the growing fruit trees.

The fluctuations in production are not affected by temperature alone. The many other factors entering the problem, however, are somewhat dependent upon it. At Least the weather has much to do in bringing about conditions which will damage the fruit crop as well as in bringing about a good crop.

It is rather hard to specifically state how much damage is done to fruit in any one year and to determine an average annual loss. Figure 3 for the individual years shows that there is a great deal of irregularity in the frequency of killing temperatures. Nothing definite is possible in predictions—the place, according to the past weather records, with the greatest chances of being free from low temperature drops can be best used for a profitable fruit-growing region. The many factors entering into this decision makes the problem one of difficulty and yet one of extreme importance financially. Fruit growers want a large percentage of their trees to produce, and they will, of course, gamble with the weather in the places which have the lowest percentage of killing temperatures over a period of years. These graphs were made from past weather reports and should bring out graphically an important reason why the fruit region is where it is, and why the presence of the lake must certainly be an influencing factor in making the climate on the leeward side favorable for fruit culture. A brief account of other weather conditions, as influenced by the lake, follows.

WIND VELOCITY

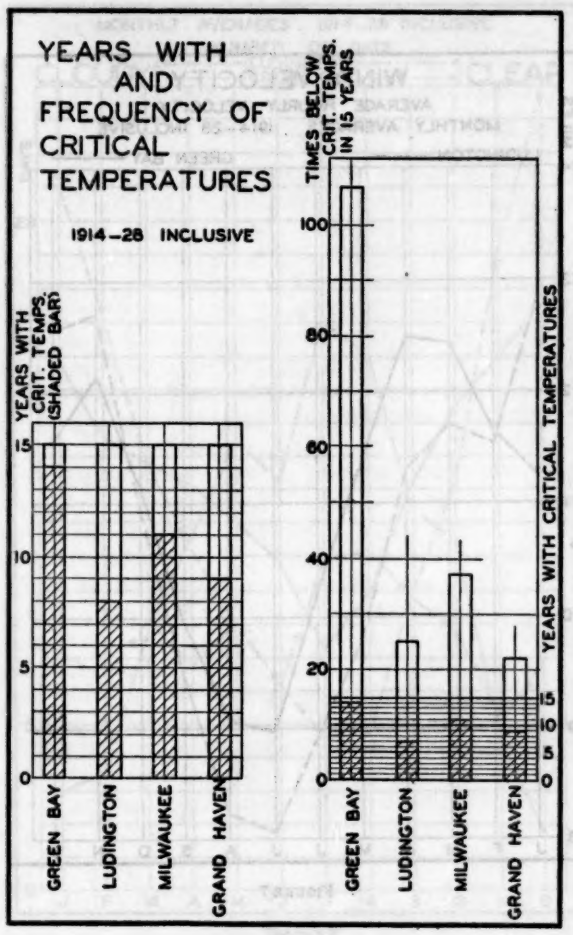
The wind velocity naturally increases in the winter season on both sides of the lake, but the increase is more pronounced on the east side than on the west because of less friction between wind and lake surface (ice or water) than between wind and land. The velocity drops during the summer—to about 9 miles per hour in July and August for the four stations. (Figs. 7 and 8.) The difference in velocity between the two shores of the lake is more pronounced to the north than to the south.

NUMBER OF CLEAR DAYS AND CLOUDY DAYS

Winter is the season of greatest number of cloudy days on both sides of the lake, while summer is the period of greatest number of clear days. (Figs. 9 and 10.) There is a greater annual range in number of clear and cloudy days in the east than on the west side of the lake. December and January each have about seven more cloudy days on the east than on the west shore, while in the summer the difference in number of clear days is not so great. The trend for partly cloudy days would more nearly resemble that of clear than that of cloudy days.

PRECIPITATION

In total annual precipitation there is little difference between the two sides of the lake in the same latitude, but there is a rather striking difference in seasonal dis-



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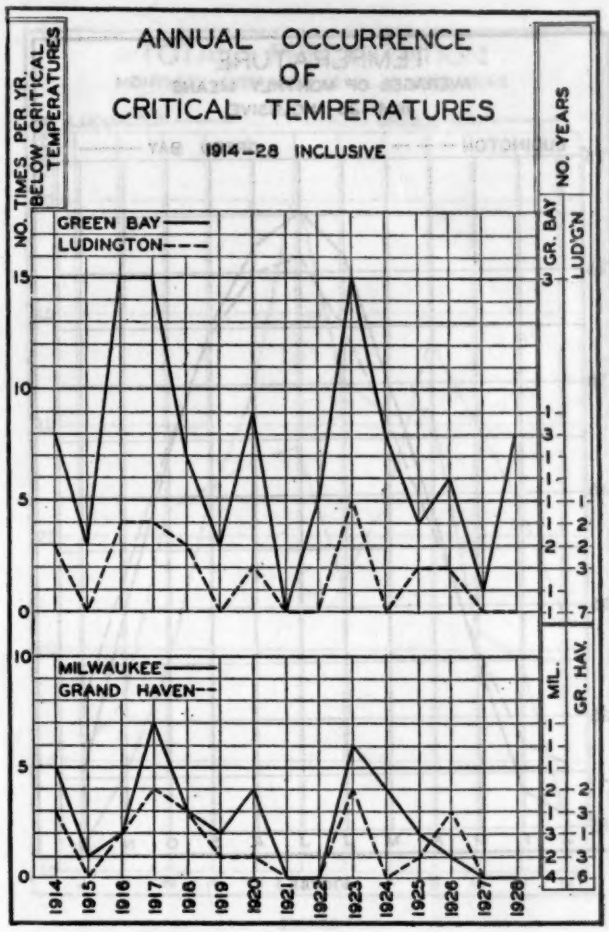

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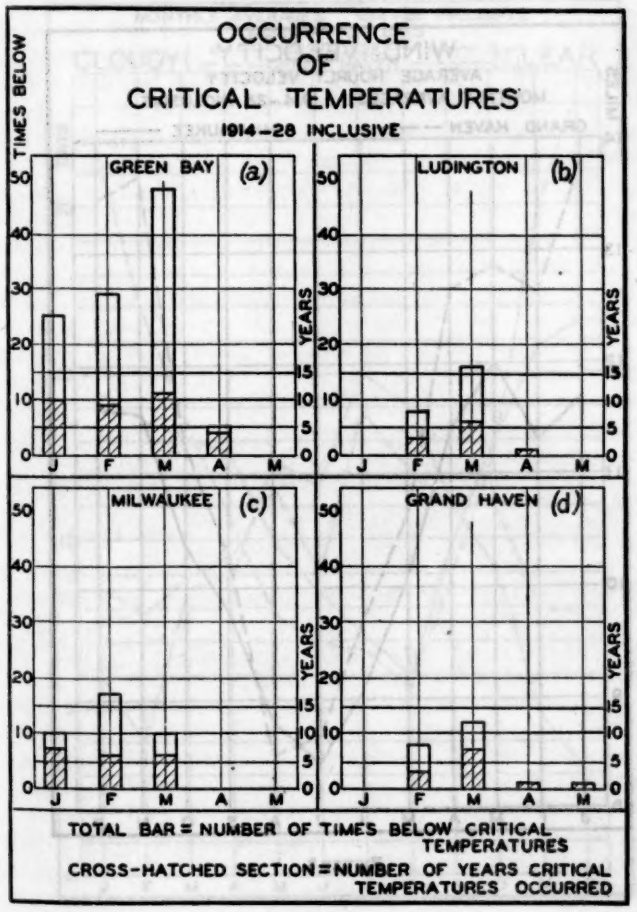

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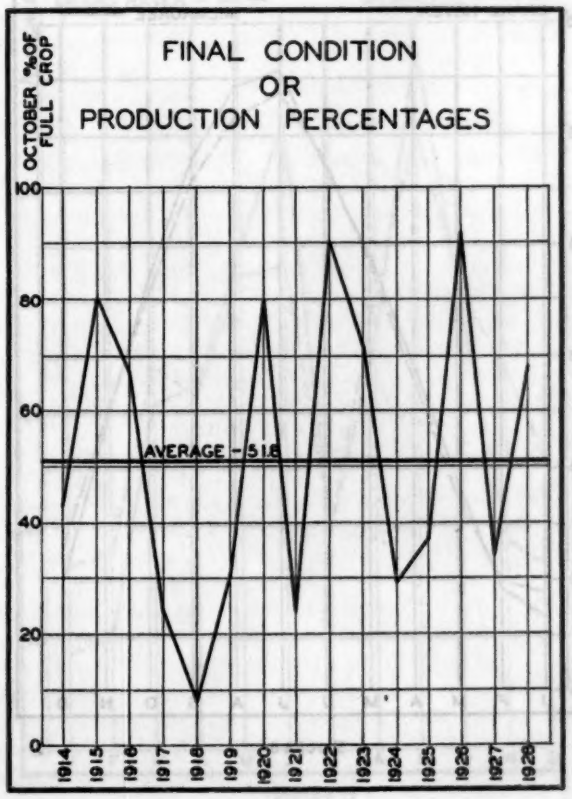

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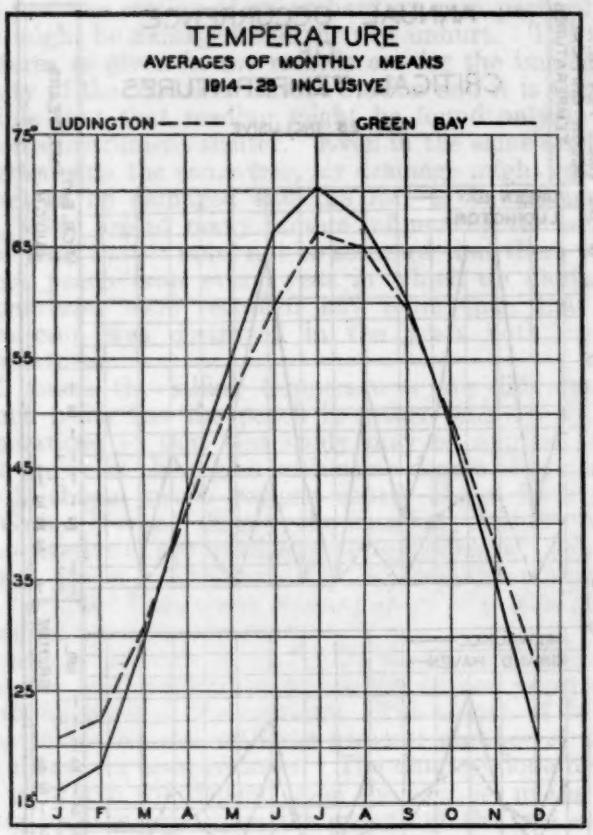

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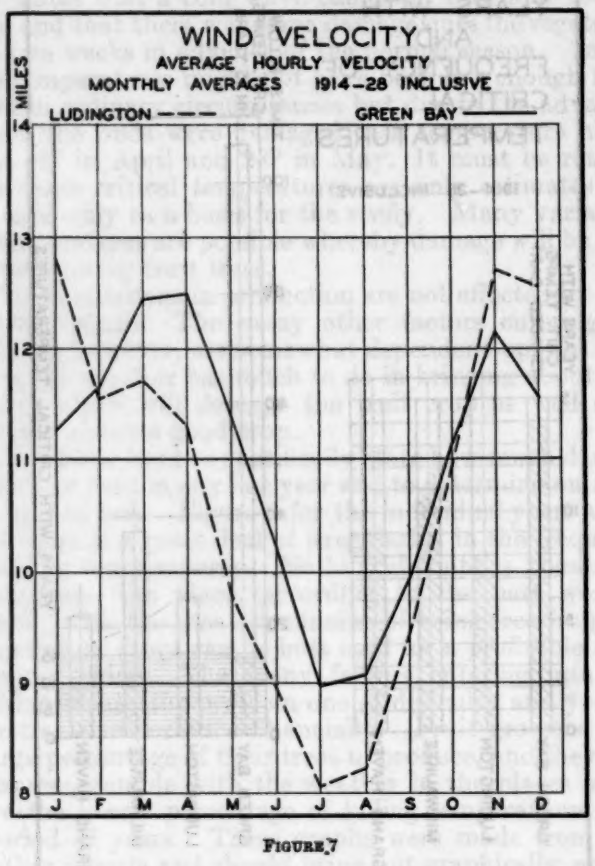

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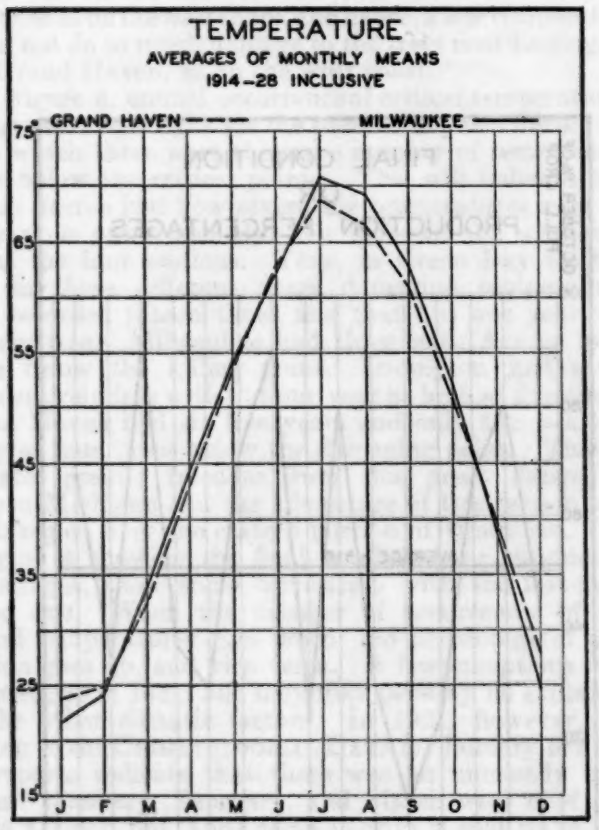

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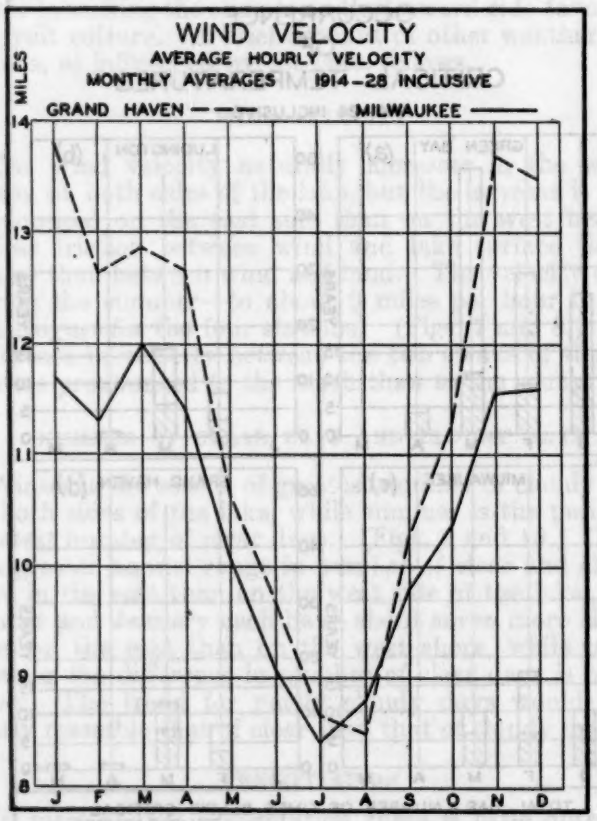

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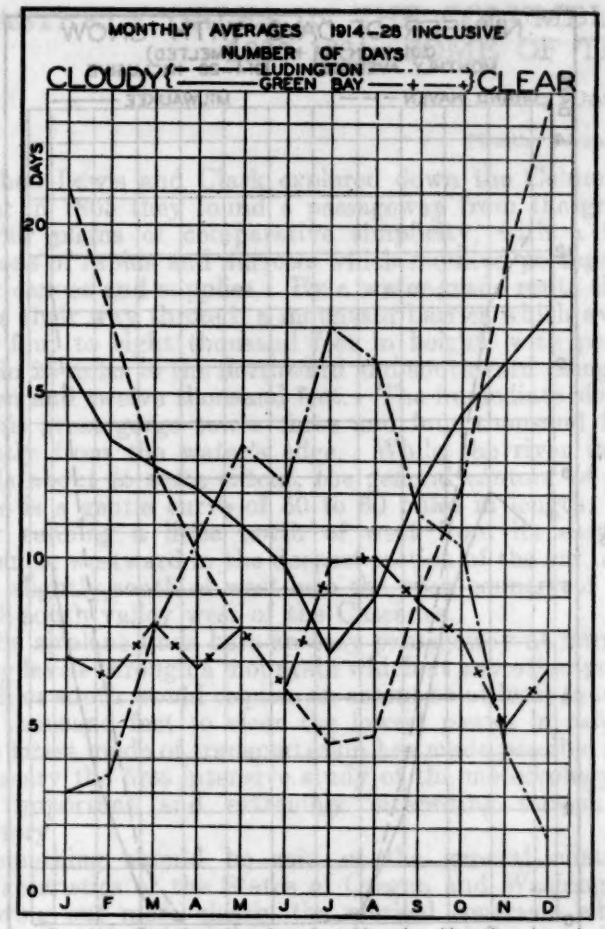

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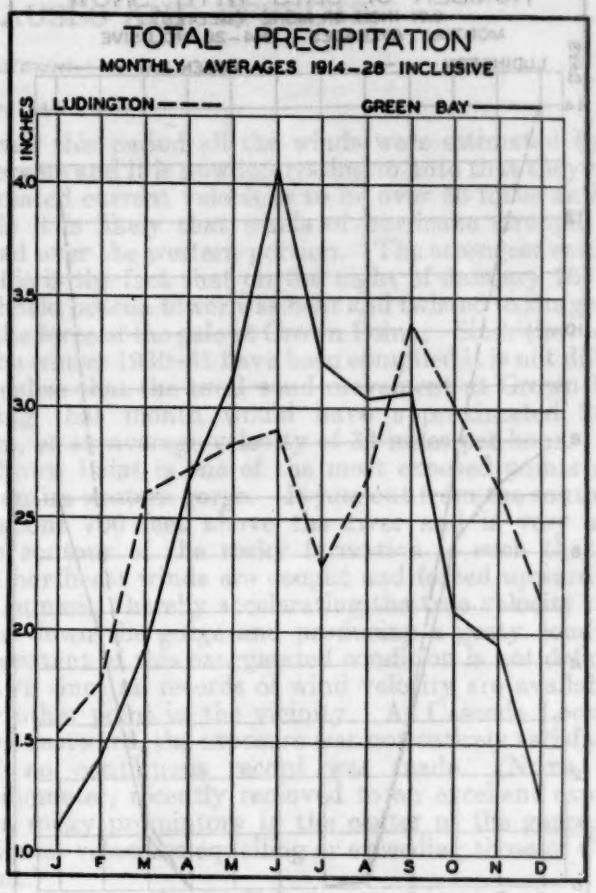

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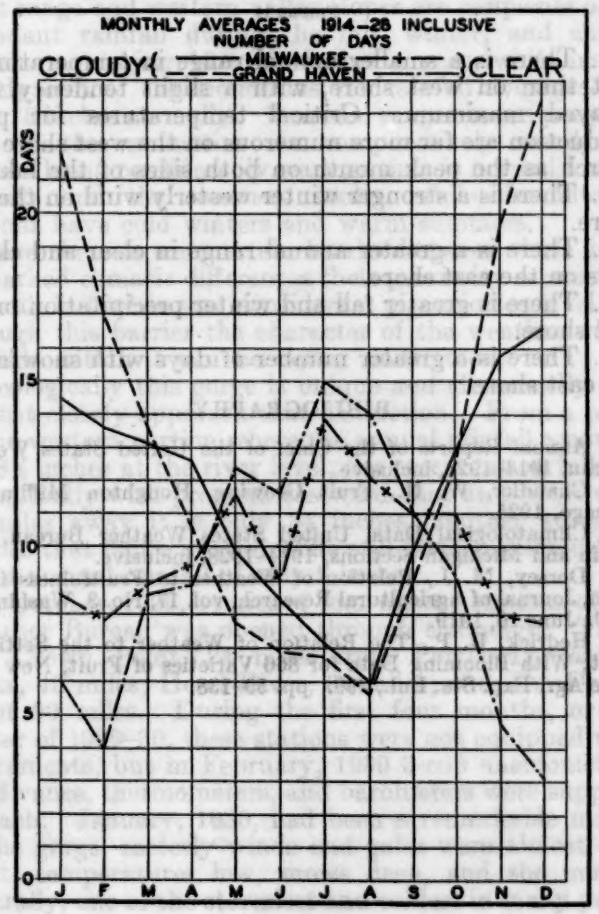

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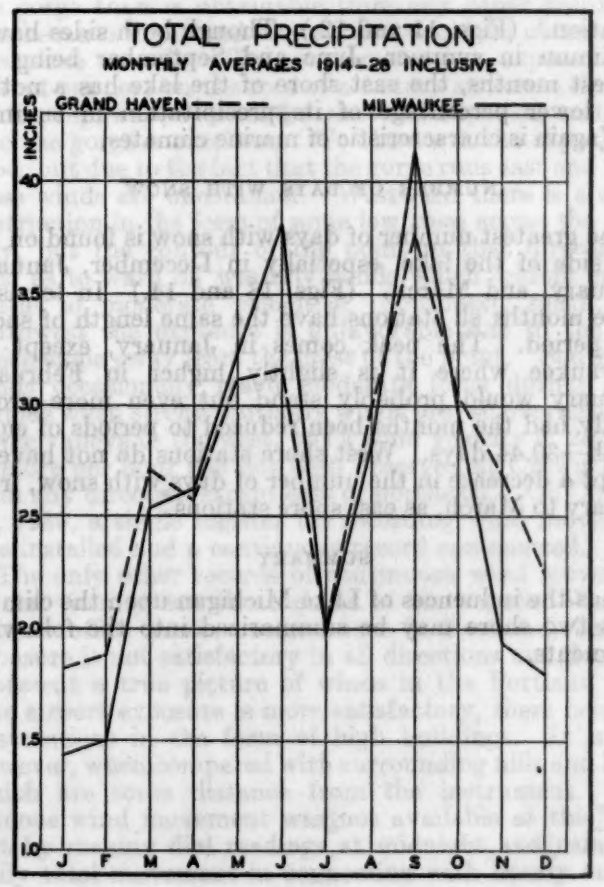

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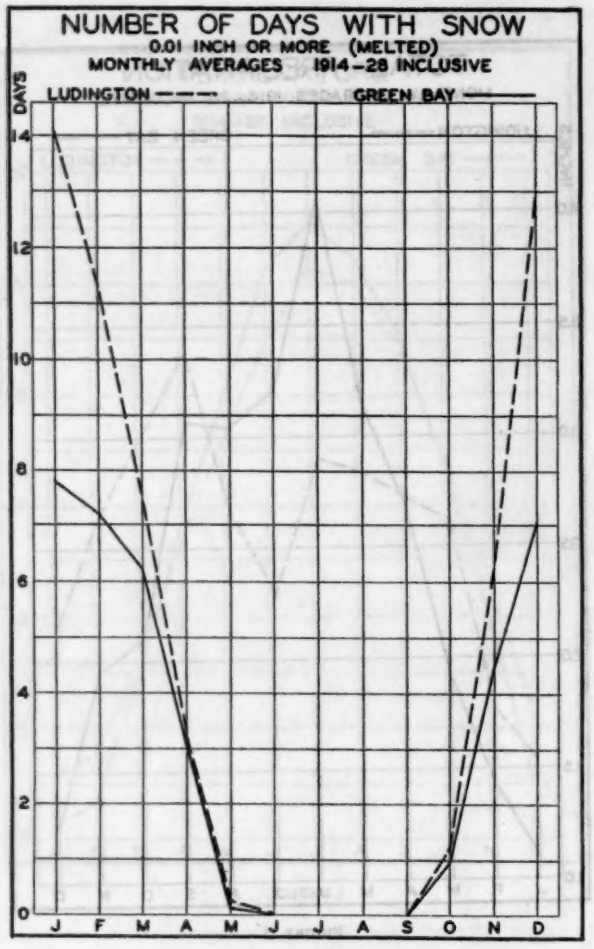

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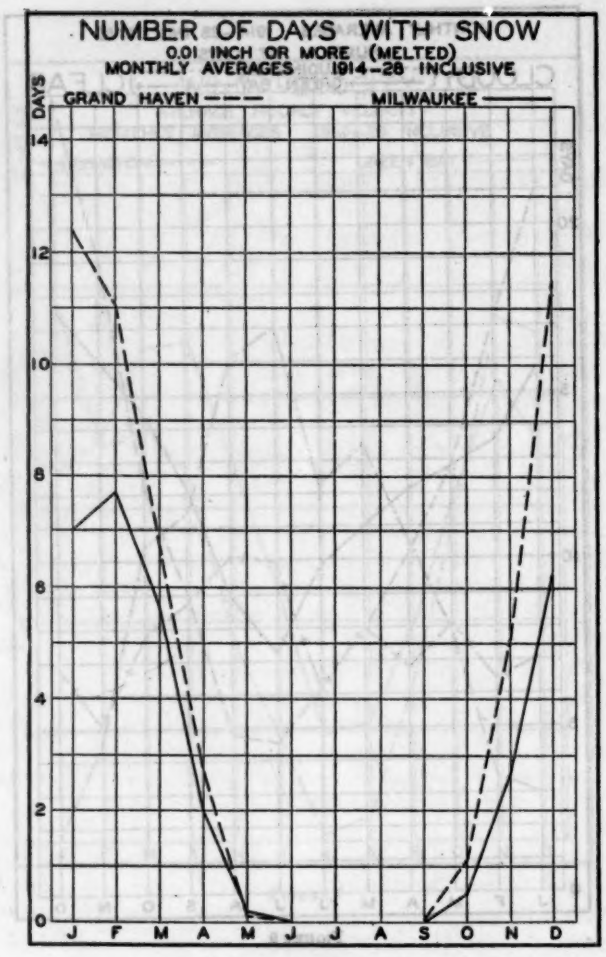

FIGURE 14

tribution. (Figs. 11 and 12.) Though both sides have a maximum in summer, June and September being the rainiest months, the east shore of the lake has a noticeably lower percentage of its precipitation in summer. This again is characteristic of marine climates.

NUMBER OF DAYS WITH SNOW

The greatest number of days with snow is found on the east side of the lake, especially in December, January, February, and March. (Figs. 18 and 14.) In terms of whole months all stations have the same length of snow-free period. The peak comes in January, except for Milwaukee where it is slightly higher in February. February would probably stand out even more prominently had the months been reduced to periods of equal length—30.44 days. West shore stations do not have so abrupt a decrease in the number of days with snow, from January to March, as east shore stations.

SUMMARY

Thus the influences of Lake Michigan upon the climate of its two shore may be summarized into the following statements,

1. There is a smaller annual range in temperature on east than on west shore, with a slight tendency for a delayed maximum. Critical temperatures for peach production are far more numerous on the west shore with March as the peak month on both sides of the lake.
2. There is a stronger winter westerly wind on the east shore.
3. There is a greater annual range in clear and cloudy days on the east shore.
4. There is greater fall and winter precipitation on the east shore.
5. There is a greater number of days with snowfall on the east shore.

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EASTERLY GALES IN THE COLUMBIA RIVER GORGE DURING THE WINTER OF 1930–1931—SOME OF THEIR CAUSES AND EFFECTS

By DONALD C. CAMERON

[Weather Bureau, Portland, Oreg., June 6, 1931]

When Lewis and Clark explored down the Columbia River in 1805 they found a passageway from the great interior plains of comparative simplicity, with a few sections of rapids and narrows which required portage of their canoes and supplies. By a water-grade route they made their way through a mountain barrier which averages four to eight thousand feet in height, with peaks within 25 miles to the northward and southward rising to eleven and twelve thousand feet. The immediate slopes of this great gorge tower three and four thousand feet directly from the water's edge. While the river itself winds about to some extent, the general contour of the gorge is a gentle curve of 50 to 60 miles in length, the river running a little north of west from its eastern entrance, westward in the deepest section of the cut, and then slightly south of west into the open country of the north-south valley west of the Cascades.

The airplane finds here an easy passageway at normal flying levels through a mountain which at any other point north or south would require an ascent to at least four or five thousand feet to clear the lowest passes in safety. This latest mode of transportation has made possible and necessary the first intensive study of the meteorology of this important and extremely interesting stretch of territory.

Something should be said of the general climatic characteristics of the States of Oregon and Washington to bring out more clearly the marked contrasts which exist east and west of this narrow mountain chain. The coast range and western valley slopes are recipients of an abundant rainfall during the fall, winter, and spring months, averaging 40 to 80 inches a year, while immediately east of the mountains the rainfall averages less than 15 inches annually. Seasonal ranges in temperature west of the mountains are comparatively small, the winters being considerably warmer than is normal for the latitude and the summers cooler, while the interior sections have cold winters and warm summers.

Since there is a mountain barrier between these areas of marked climatic differences their proximity seems only natural, but when one considers a gigantic sea-level cut through this barrier the character of the weather which prevails within it can be better understood.

Geologically this gorge is unique and climatically also it must closely approach that distinction. From a place in the western portion where the annual rainfall amounts to 78½ inches at the river level, the precipitation falls off so markedly with progress eastward that at a point only 18 miles away it is only 34 inches, another 18 miles divides that figure in two, while still farther eastward we find a normal rainfall of only 8 inches.

In October, 1929, a series of four airway stations of the Weather Bureau was opened through the gorge. These are: Crown Point, 24 miles from Portland; Cascade Locks, 45 miles; Hood River, 65 miles; and The Dalles, about 90 miles. During the first four months, or the winter of 1929–30, these stations were not equipped with instruments, but in February, 1930 3-cup anemometers, wind vanes, thermometers, and barometers were supplied to each. January, 1930, had been a remarkable month in the gorge, easterly winds and gales were almost constant, temperatures low, snows deep, and the month, generally, one of the stormiest and coldest in many years. During this period all the winds were estimated by the observers and it is now interesting to note that they never estimated current velocities to be over 50 miles an hour, while it is likely that winds of hurricane strength prevailed over the western portion. The strongest evidence of this is the fact that on the night of January 16–17, a Richfield beacon tower was bent and twisted to the ground by the force of the gale at Crown Point. Since the records of the winter 1930–31 have been compiled it is not difficult to realize that the total wind movement at Crown Point during that month would have approximated 25,000 miles, or an average velocity of 34 miles per hour.

Crown Point is one of the most exposed points along the entire western gorge. It juts out from the south wall at about 700 feet above the river and is very steep. The contour of the rocky formation is such that east and northeast winds are caught and forced upward over the summit, thereby accelerating the true velocity of the wind down the gorge and producing a gusty condition. The extent of this exaggerated condition is not definitely known since no records of wind velocity are available at any other point in the vicinity. At Cascade Locks, 20 miles eastward, the exposure was not entirely satisfactory and no continuous record was made. (NOTE.—The anemometer, recently removed to an excellent exposure on a rocky promintory in the center of the gorge, now indicates velocities equalling or exceeding those of Crown Point.)

The site at Crown Point was selected for a station because it commands a better view of a greater portion of the gorge than is obtainable from any other point and also because night and day service could be obtained at this place on call. The anemometer was exposed on a 12-foot support on the roof of a 1-story structure directly on the highway, so situated that the exposure eastward into the gorge is excellent. To the north the exposure is good, but due to the fact that the gorge runs east and west, cross winds are uncommon. Westward there is a slight obstruction in the form of some low trees across the highway, but the contour of the point in that direction is such as to ward off westerly winds which seldom exceed gentle to moderate velocities. Southeast, south, and southwest the exposure is unfavorable due to the hills which slope away from the crest of the point. Southwest winds occasionally reach moderate force during rainy periods when strong southerly winds prevail overhead and in the valleys to the west, but a wind velocity of 20 miles or more per hour has not been observed at Crown Point from any direction except east or northeast. On October 21, 1930, a single register for recording wind movement was installed and a continuous record commenced.

The only other records of continuous wind movement in the vicinity are those made at the regular Weather Bureau office in the customhouse in Portland, but the exposure is not satisfactory in all directions and does not represent a true picture of winds in the Portland area. The airport exposure is more satisfactory, there being no obstructions in the form of high buildings. It is low, however, when compared with surrounding hills and bluffs which are some distance from the instrument. Continuous wind movement was not available at this point but by making dial readings at midnight and using the daily total movement in connection with hourly current

velocities a very satisfactory record of total movement was obtained which represents more nearly the average conditions in the immediate Willamette Valley than does the customhouse record. Finally, dial readings were commenced on the 3-cup anemometer exposed on the summit of Council Crest in Portland. This exposure is without parallel in the Pacific Northwest, being 1,200 feet above the Willamette River and 88 feet above ground at the summit. Access to this point by automobile is fairly easy and dial readings were made every four or five days. The record obtained, however, is only for total wind movement but it represents a record of unobstructed flow of wind from all directions above the Portland area.

November, 1930, was the first complete month of record at these points and the following is a table of the wind data:

	Total	Average	Prevailing direction	Maximum velocity and direction
	Miles	*M. p. h.*		
Crown Point	12,580	17.5	NE	70 NE.
Council Crest	10,711	14.9	NE	
Portland Airport	4,496	6.2	SE	
Customhouse	3,481	4.8	SE	20 E.

From the above table it can be seen that Crown Point's total is 3.6 times that of the customhouse, 2.8 times that of the airport, but only 1.1 times that of Council Crest. During this month, the wind at Crown Point blew from the northeast 37 per cent of the time and 71 per cent of the total mileage, while at the customhouse the wind blew from the northeast only 4 per cent of the time and 3 per cent of the total mileage. Southeast was the prevailing direction in the city, the customhouse showing 31 per cent of the time and 30 per cent of the mileage from that direction, the airport 32 per cent of the time and 40 per cent of the mileage. This is the direction which occurs at these two exposures most of the time that strong northeast and east winds prevail at Crown Point. Another very interesting feature of the Crown Point wind during November is that the northeast wind averaged 33.2 miles per hour, the east wind 14.1, while no other direction gave over 6.5. The most remarkable period was from the 22d to the 26th, inclusive, when the wind blew from the northeast every hour of the 120 of the period and averaged 40.1 miles per hour! Equally remarkable is the record from the 21st to the 30th, inclusive, when the wind averaged 33.6 miles per hour and blew from the northeast or east every one of the 240 hours. At the customhouse during the former period the wind averaged 5.6 miles per hour, and during the 10-day period, 5.1 miles, the airport averaging slightly higher than the customhouse. These differences are surprising when one considers that there is no marked barrier in the way of hills between Crown Point and downtown Portland.

November 23d was the windiest day at Crown Point, there being a total movement of 1,278 miles that day, an average of 53.2 miles per hour. The writer had the pleasure of being at the Point during a portion of the day, but not during the time of the maximum wind, which occurred during the morning. Observing the clock closely and counting the buzzes on the wind indicator during some of the heavier gusts, an extreme velocity of 120 miles an hour was noted. The tops of several automobiles were wrecked as they rounded the Point; one woman was thrown to the pavement by the gale and rolled against a stone abutment, suffering injuries which required hospital treatment.

The greatest total movements were recorded during December, 1930, but no unusually high maxima occurred. The following table is for December:

	Total	Average	Prevailing direction	Maximum velocity and direction
	Miles	*M. p. h.*		
Crown Point	17,135	23.0	NE	60 NE.
Council Crest	12,849	17.3	NE	
Portland Airport	5,520	7.4	SE	
Customhouse	4,071	5.5	E	20 E.

The total movement at Crown Point is unusually high, and an inspection of the total movements at regular Weather Bureau stations since the installation of 3-cup anemometers in January, 1928, reveals that it has been exceeded at only two, namely, by 4 miles at Buffalo during January, 1928, and at Tatoosh Island, Wash., during January, 1930, when a total of 17,947 miles was recorded. It is interesting to note that during December, 1930, the total movement at Tatoosh was only 12,718 miles, or 74 per cent of that at Crown Point. The wind movement at Crown Point during the month was over four times that recorded at the customhouse, over three times that at the airport, and 1.3 times that of Council Crest; 96 per cent of the Crown Point total movement was from the northeast or east, while it blew 71 per cent of the time from those directions. The northeast wind averaged 33.8 miles per hour, the east wind 15.6 miles per hour, but winds from other directions averaged only 6.5 miles per hour or less. In Portland the northeast wind as usual was negligible, while the southeast wind at the airport blew 54 per cent of the time, 68 per cent of the total mileage, and averaged 9.5 miles per hour. At the customhouse, east was the prevalent wind, blowing 34 per cent of the time, 49 per cent of the mileage, and averaging 7.7 miles per hour. The difference between the effects of these latter two exposures on east and southeast winds is almost wholly of topographical origin.

During January, 1931, large total movements were registered at the Point and at Council Crest, shown with the airport and customhouse figures in the following table:

	Total	Average	Prevailing direction	Maximum velocity and direction
	Miles	*M. p. h.*		
Crown Point	13,597	18.3	NE	54 NE.
Council Crest	12,530	16.8	SW	
Portland Aircraft	5,686	7.6	SE	
Customhouse	3,883	5.2	SE	30 S.

Comparisons during this month show approximately the same differences as during the two preceeding months, except that Council Crest's total approaches Crown Point's, due to the fact that southerly winds were more frequent over Portland than earlier in the winter.

February, 1931, is somewhat more striking in that the wind at Council Crest exceeds that at Crown Point for the first month since the study was commenced. The values for this month are shown in the table following.

	Total	Average	Prevailing direction	Maximum velocity and direction
	Miles	*M. p. h.*		
Crown Point	10,496	15.6	NE	54 NE.
Council Crest	10,585	15.8	NE	
Portland Airport	4,711	7.0	SE	
Customhouse	3,560	5.3	E	24 SW.

Due to the shortness of the month, total movements are proportionately lower, but Council Crest exceeds Crown Point in total movement by approximately 100 miles.

In the following table a brief summary of the four months, November, 1930–February, 1931, inclusive, is presented:

	Total	Average	Prevailing direction	Maximum velocity and direction
	Miles	*M. p. h.*		
Crown Point	53,808	18.7	NE	70 NE.
Council Crest	46,675	16.2	NE	
Portland Airport	20,413	7.0	SE	
Customhouse	14,995	5.2	SE	30 S.

From this it can be seen that Crown Point's total was approximately 3.6 times that at the customhouse, about 2.6 times that at the airport, but only 1.2 times that of Council Crest. However, when one considers that almost the entire mileage at Crown Point was from only two directions, viz., northeast and east, compared with free wind movement from all points at Council Crest, the difference is even more remarkable.

The causes of the easterly gales are interesting and as would be expected are due principally to the fact that during the winter time higher pressure prevails over the continent and lower pressure over the sea. The Cascades form a natural barrier between these pressure differences and steep gradients occasionally occur along the range, It is at these times, of course, that winds at Crown Point are strongest, slackening as the gradient lessens, and disappearing almost entirely when the pressure distribution is reversed. However, other important factors contribute to the strength of the gales, principally temperature. Colder weather accompanies high pressure east of the mountains, while to the westward warm weather with southeast or southerly winds may prevail and this temperature gradient is frequently very strong over the mountains, while the pressure gradient may not be unusual. Strong winds are experienced under such conditions. With the movement inland of a low-pressure area in British Columbia a change of the pressure graddient occurs. Often the gradient over the range is reversed in a comparatively short period. At these times, a flow of colder air from the interior obtains and occasionally lasts for several hours before finally being overcome by the more powerful pressure differences. This change was observed frequently during the winter of 1930–31 and on a few occasions caused glaze deposits in the vicinity of the Point when subfreezing temperature prevailed in the easterly winds from the interior while westward and aloft relatively warm weather accompanied by rain was occurring.

The return of the easterly winds was always a slow and gradual process attending the passage of the oceanic high pressure areas inland over the Cascades, and during such times the temperature gradients were unimportant. The wind did not shift to easterly until the center of the high pressure definitely passed over the range, after which the increase in velocity was slow and steady. However, if a strong continental high had moved southward into the interior, the shift and increase in wind might have been abrupt and accompanied by a cold wave. No such cases occurred during the winter, but during the great wind and dust storm of April 21–24, 1931, a somewhat similar case did occur and the wind at Crown Point rose abruptly from 20 to 50 miles per hour with the arrival of the wind shift. (NOTE.—MONTHLY WEATHER REVIEW, May, 1931, p. 195.)

Conditions of pressure and temperature during the winter 1930-31 were decidedly abnormal, especially as regards the persistence of the pleateau high over Idaho and eastern Oregon. During a normal winter such remarkably steady and prolonged gales would not be experienced, but quite likely some higher maximum velocities would occur. An ideal type for winds of hurricane strength would be a strong high moving southward into eastern Washington and Oregon from Canada and an oceanic low-pressure area off the central Oregon coast. Just such a pressure distribution occurred on the night of January 16–17th, 1930, when the destruction of the steel tower, described previously, took place.

Results of the easterly gales in the Columbia River gorge are many and varied but space does not permit their being discussed in detail. In general they are responsible for more uniformly low daytime temperatures at Portland and higher night temperatures during clear, winter weather, while northward and southward away from the effects of the gorge winds much larger ranges in temperature occur. Perhaps one of the most beneficial effects of the gorge winds in the Portland area is their reduction in the hours of ground fog as compared with other sections any distance north or south, where marked temperature inversions occur during clear, calm nights. The motion of the air in the Portland area and its relative dryness are the principal causes for lack of fog. While it must be admitted that the winter of 1930–31 was one of unusual fogginess in the valleys between the Cascades and the Coast Range, due to persistence of high pressure over the interior of the Northwestern States and resulting clear skies, the following table has been prepared to show the number of hours during the four month's period, November to February, with moderate or dense fog (visibility three-fourths mile or less):

	Number hours with moderate or dense fog				
	November	December	January	February	Total
Portland	96	57	47	29	229
Salem	162	180	173	65	580
Roseburg	188	135	141	80	544
Seattle	185	92	90	42	409

Salem, Roseburg, and Seattle were selected to make the comparison because they are all located in the valley country between the Cascades and Coast Range, although local topography is considerably varied, and because hourly records of fog were available.

During each of the months Portland ranked lowest in the number of hours of fog, the difference being especially marked when compared with the record at Salem (50 miles south of Portland). During December and January, Salem had over three times as many hours with fog as Portland. On no single day during the period did fog persist at Portland throughout the daylight hours, while at Seattle this condition occurred on three days, and at Salem on four days.

In reviewing the record of the easterly gales during the winter of 1930–31 only one phase of the weather in this most unique section has been described.

FREE-AIR WINDS AT SAN JUAN, P. R.

By C. L. RAY

[Weather Bureau Office, San Juan, P. R., October 13, 1931]

More than 500 pilot-balloon observations at San Juan have reached an altitude of 10 kilometers or more up to the present time (October, 1931). Pilot-balloon work was begun there in the summer of 1920, and was at first confined to the summer and autumn months, but from May, 1926 records have been obtained daily throughout the year, except when they were interrupted by inclement weather. In February, 1931, an evening observation was added to the daily program, necessarily limited, however, in altitude owing to fading, or extinguishing, of the small candle light. The number of all observations up to October, 1931, amounts to more than 3,500. On the average between 15 and 20 per cent of the daylight flights attained an altitude of 10 kilometers or higher. Although the visibility seldom is better than six to seven (fair to good), long observations are made possible by the reverse or westerly current above the "trades."

At San Juan the record of long runs is due, in part, to the unremitting interest of Dr. O. L. Fassig under whose direction this work was started in 1920.

The following summation of the seasonal averages at the several levels is of interest particularly as it relates to the winds in the upper layers of the troposphere and the lower stratosphere. With this in mind, the averages have been based on the flights which attained the 10-kilometer level or higher. A paper by Doctor Fassig in the MONTHLY WEATHER REVIEW, vol. 52, January, 1924, covers some of the more interesting records made up to that time. The following data include also such of those earlier observations as pertain to the extreme altitudes. Owing to the greater number of years in which observations were made in the summer and autumn periods, larger proportions of the data refer to those seasons than to the others. It is believed, however, that there are sufficiently numerous observations to fairly represent each of the four seasons. This grouping and also that by levels are given in Table 1.[1]

TABLE 1.—*Number of observations by seasons and different levels, San Juan, P. R.*

Observations:	
Spring	62
Summer	167
Autumn	234
Winter	44
Annual	507
Surface to—	
10 kilometers	507
11 kilometers	378
12 kilometers	271
13 kilometers	172
14 kilometers	90
15 kilometers	54
16 kilometers	25
17 kilometers	17
18 kilometers	11
19 kilometers	9
20 kilometers	8
21 kilometers	6
22 kilometers	4
23 kilometers	2
24 kilometers	2
25–33 kilometers	1

[1] The results for heights above 15 kilometers must be accepted with the reservation that they are based on single theodolite observations and therefore on an assumed ascensional rate for which sufficient confirmation data by two theodolites have not yet been obtained.

Throughout the year the surface winds frequently are from some easterly point. An east component occurred in 64 per cent of all such winds under consideration. However, the chief surface component, found in 85 per cent of the cases, is southerly, particularly in the early morning hours. This off-shore wind shifts to more easterly by 9 or 10 a. m. Table 2 gives the percentage of annual and seasonal frequencies of wind directions at the surface and in the upper levels to 10 kilometers, while Figure 1 shows the summer and winter directions percentages at the surface and at the 2, 6, and 10 kilometer levels. It will be noted that the prevailing component is easterly up to 4 kilometers in all seasons and to 6 kilometers in the summer period, and westerly at the 8 and 10 kilometer levels.

TABLE 2.—*Percentage frequency of winds observed from various directions at San Juan, P. R.*

SPRING

Altitude (meters)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Surface	0	0	0	10	15	15	25	20	11	2	2	0	0	0	0	0
1,000	0	2	0	6	36	38	18	0	0	0	0	0	0	0	0	0
2,000	0	3	0	20	28	25	12	5	3	1	0	1	1	0	0	1
4,000	5	7	7	12	25	7	3	2	6	1	8	3	3	5	3	3
6,000	12	12	3	12	3	0	3	0	0	2	8	14	8	14	6	3
8,000	2	6	5	0	2	0	0	0	0	0	3	20	8	28	16	10
10,000	3	1	0	0	0	0	0	0	0	1	1	3	33	35	13	10

SUMMER

Surface	0	0	0	6	16	18	26	15	12	3	2	1	1	0	0	0
1,000	1	0	0	2	40	39	14	2	1	1	0	0	0	0	0	0
2,000	0	1	1	11	28	36	15	3	2	1	0	1	0	0	0	1
4,000	2	5	10	15	17	16	14	7	4	3	3	2	0	0	1	1
6,000	6	5	10	13	11	9	10	4	4	3	5	5	5	4	3	3
8,000	7	3	5	5	6	3	4	2	7	5	5	12	11	7	11	7
10,000	6	6	9	5	3	3	2	3	3	4	7	12	16	11	5	5

AUTUMN

Surface	0	0	1	1	2	5	16	26	30	15	3	1	0	0	0	0
1,000	0	1	4	11	22	30	16	5	5	2	0	1	1	1	1	0
2,000	2	4	4	9	23	20	14	7	3	3	2	2	2	2	2	1
4,000	5	4	10	11	9	11	5	6	9	6	7	4	6	1	3	3
6,000	6	8	7	6	5	6	5	5	8	9	6	7	6	7	3	6
8,000	10	8	7	5	4	3	3	3	4	6	9	8	11	8	4	7
10,000	9	8	5	3	3	3	3	2	2	4	5	6	12	13	9	13

WINTER

Surface	0	0	0	2	0	7	16	27	30	11	7	0	0	0	0	0
1,000	2	0	5	15	48	18	5	5	0	0	0	2	0	0	0	0
2,000	2	7	2	20	25	23	9	0	0	0	0	5	2	5	0	0
4,000	0	7	4	16	16	14	2	2	0	7	5	2	11	0	9	5
6,000	2	11	11	0	5	11	5	2	0	7	2	11	16	5	5	7
8,000	2	7	7	0	2	0	6	0	0	5	9	14	25	5	7	11
10,000	2	0	0	4	0	0	0	0	0	5	0	14	27	23	14	11

ANNUAL

Surface	0	0	0	4	8	11	20	22	22	9	3	1	0	0	0	0
1,000	1	1	2	8	32	33	15	3	3	1	0	1	0	0	0	0
2,000	1	3	2	12	26	26	14	5	2	2	1	2	1	1	1	1
4,000	4	5	9	13	13	13	7	6	6	5	5	3	4	1	3	3
6,000	6	6	8	9	7	7	6	4	5	6	6	8	7	6	4	5
8,000	7	6	6	4	4	2	5	2	4	5	7	11	11	10	8	8
10,000	7	5	5	3	2	2	2	2	2	4	5	9	17	16	9	10

Table 3 shows the frequencies of different wind components at and above the 10-kilometer level. North and west components persist up to 15 kilometers, then south

and west or south and east to 16 or 17 kilometers, and finally, north and east components at the 18 to 22 kilometer levels. Two flights were followed to a height of 24 kilometers and one to 33 kilometers. The latter is discussed in detail in the MONTHLY WEATHER REVIEW, January, 1924, referred to above.

TABLE 3.—*Percentage frequency of wind components in levels at and above 10 kilometers*

Direction between—	Kilometers												
	10	11	12	13	14	15	16	17	18	19	20	21	22
SSW. and NNW. (W.)	70	69	65	70	60	69	52	29	27	0	25	33	22
SSE. and NNE. (E.)	21	22	24	20	31	24	36	41	73	78	62	67	75
ESE. and WSW. (S.)	26	22	27	28	34	35	56	53	36	11	38	33	0
WNW. and ENE. (N.)	55	63	56	53	54	56	28	29	45	44	50	50	75
No. of observations	507	398	271	172	91	54	25	17	11	9	8	6	4

NOTE.—2 observations to 24 kilometers with ENE. to E. and ESE. to WNW. at 23 and 24 kilometers respectively; 1 observation to 33 kilometers with change in direction from 25 kilometers to 33 kilometers, in the following shift—W. to SE. to S. to WNW. to SW. at 33 kilometers, velocity 3 to 15 meters per second.

Owing to the small number of observations at the higher levels their averages are somewhat unreliable. There seems, however, to be a well-defined north by westerly current from the 7-kilometer level to the fifteenth, and a fairly continuous east component in the winds above the 17-kilometer level.

TABLE 4.—*Mean free-air winds at San Juan, P. R.*

[Velocity in meters per second]

Altitude (meters)	Spring		Summer		Autumn		Winter		Annual	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
Surface	S-48-E	3.0	S-47-E	2.3	S-15-E	1.9	S-14-E	2.2	S-29-E	2.2
500	S-77-E	8.7	S-75-E	8.2	S-70-E	5.9	S-87-E	7.6	S-74-E	7.1
1,000	S-75-E	9.2	S-72-E	8.7	S-70-E	5.9	S-82-E	7.9	S-72-E	7.4
2,000	S-79-E	6.1	S-74-E	7.4	S-76-E	5.0	N-87-E	6.0	S-77-E	6.0
3,000	N-77-E	5.5	S-73-E	6.3	S-68-E	4.4	N-77-E	5.1	S-76-E	5.2
4,000	N-82-E	4.9	S-81-E	5.3	S-76-E	4.1	N-74-E	5.0	S-81-E	4.7
5,000	N-40-W	4.9	E	5.1	S-49-E	4.8	N-14-E	5.8	S-83-E	5.2
6,000	N-43-W	6.6	N-83-E	4.8	S-15-W	4.8	N-40-W	7.2	N-53-E	5.2
7,000	N-53-W	8.5	N-12-W	5.2	N-73-W	5.5	N-58-W	9.0	N-47-W	6.0
8,000	N-59-W	10.9	N-58-W	6.1	N-56-W	6.6	N-77-W	9.4	N-60-W	7.2
9,000	N-66-W	14.2	N-67-W	6.3	N-51-W	7.3	N-74-W	13.1	N-62-W	8.3
10,000	N-70-W	18.0	N-69-W	8.1	N-43-W	9.5	N-73-W	17.0	N-60-W	10.7
11,000	N-69-W	18.4	N-65-W	9.2	N-50-W	10.7	N-74-W	21.9	N-60-W	11.5
12,000	N-71-W	18.1	N-67-W	9.5	N-44-W	11.4	N-73-W	21.6	N-58-W	12.0
13,000	N-72-W	19.4	N-69-W	9.8	N-61-W	12.2	N-68-W	20.3	N-65-W	12.5
14,000	N-62-W	21.0	N-87-W	10.5	N-50-W	11.5	N-20-W	22.0	N-65-W	13.0
15,000	N-68-W	20.8	N-49-W	13.0	N-68-W	12.8	N-19-W	22.0	N-59-W	14.9

Table 4 gives the mean free-air winds and Table 5 the free-air resultant winds, by seasons and for the year from the surface to the 15-kilometer level.[2] Figure 2 shows the mean free-air wind directions and velocities. Here we note that in the spring the wind is easterly below the 4-kilometer level and westerly above; in the summer, easterly up to the 6-kilometer level but westerly at and beyond 7 kilometers; in autumn and winter, easterly up to 5 kilometers and westerly at and above 6 kilometers. In the free-air resultant winds no marked difference in direction occurs, compared with that of the average winds, but there is some reduction in velocity which is particularly evident in the summer and autumn months when the persistence of easterly winds to higher levels tends to lower the values of the resultant westerly speeds.

[2] In obtaining "mean" or "average" winds the directions and velocities are considered independently, whereas, "resultant" winds are determined by first resolving each observation into its north and west components and then adding these vectorially.

TABLE 5.—*Free-air resultant winds at San Juan, P. R.*

[Velocity in meters per second]

Altitude (meters)	Spring		Summer		Autumn		Winter		Annual	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
Surface	S-73-E	2.3	S-59-E	1.9	S-19-E	1.5	S-22-E	1.6	S-42-E	1.8
500	S-79-E	8.3	S-73-E	7.7	S-73-E	5.0	S-88-E	7.0	S-76-E	6.5
1,000	S-75-E	8.2	S-77-E	8.0	S-72-E	4.9	S-78-E	7.3	S-77-E	6.7
2,000	S-82-E	5.1	S-75-E	6.7	S-75-E	3.5	N-88-E	4.5	S-77-E	4.8
3,000	N-89-E	3.5	S-82-E	3.4	S-73-E	2.0	N-73-E	2.8	S-82-E	2.7
4,000	N-85-E	2.2	S-80-E	3.5	S-71-E	1.4	N-67-E	1.7	S-82-E	2.1
5,000	N- 5-W	0.7	N-88-E	2.7	S-54-E	0.6	N-88-E	0.2	S-88-E	1.2
6,000	N-43-W	2.4	N-84-E	1.4	N-39-W	0.4	N-14-W	0.8	N-31-E	0.6
7,000	N-55-W	5.0	N-34-W	0.6	N-34-W	0.9	N-70-W	3.4	N-51-W	1.2
8,000	N-64-W	8.8	N-52-W	2.0	N-50-W	1.6	N-81-W	5.0	N-61-W	2.7
9,000	N-66-W	11.5	N-69-W	2.2	N-46-W	2.9	N-77-W	9.0	N-62-W	4.0
10,000	N-74-W	16.7	N-75-W	3.2	N-39-W	4.5	N-76-W	14.6	N-64-W	6.0
11,000	N-72-W	16.8	N-68-W	4.0	N-50-W	5.4	N-76-W	19.7	N-76-W	6.0
12,000	N-72-W	16.9	N-64-W	3.8	N-47-W	5.9	N-80-W	20.0	N-61-W	6.7
13,000	N-72-W	19.4	N-80-W	4.4	N-59-W	6.4	N-75-W	16.8	N-68-W	7.1
14,000	N-57-W	16.4	N-86-W	4.1	N-55-W	3.6	N-17-W	18.7	N-65-W	5.8
15,000	N-68-W	20.8	N-61-W	8.1	N-60-W	4.4	N-17-W	16.9	N-52-W	7.8

The proportion of clockwise to counter-clockwise east-to-west shifts, which generally occur near the 6-kilometer level, was tabulated for each season. An average of 65 per cent turn counter-clockwise in the winter and spring months, and 54 per cent during summer. In the autumn, when the southeast trades are deeper, 52 per cent of the shifts are clockwise.

TABLE 6.—*Free-air resultant winds at San Juan, P. R. (1926–1931)*

[Velocities in meters per second]

Altitude (meters)	Spring		Summer		Autumn		Winter		Annual		Observations
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	
Surface	S-83-E	2.5	S-82-E	2.9	S-65-E	1.6	N-86-E	2.7	S-82-E	2.5	1,725
500	S-81-E	7.9	S-83-E	8.6	S-86-E	7.6	N-82-E	7.6	S-87-E	7.6	1,725
1,000	S-79-E	7.9	S-78-E	9.6	S-83-E	6.7	N-84-E	8.0	S-84-E	8.0	1,709
2,000	S-81-E	5.0	S-78-E	8.6	S-83-E	5.3	N-82-E	6.3	S-84-E	6.1	1,496
4,000	S-7-W	0.2	S-78-E	4.6	S-81-E	2.5	N-66-E	2.6	S-85-E	2.2	985
6,000	N-78-W	4.8	S-76-E	1.7	N-59-E	1.0	N-54-W	2.9	N-59-W	1.3	668
8,000	N-72-W	8.9	N-65-W	1.1	N-15-W	1.8	N-74-W	8.9	N-66-W	4.2	458
10,000	N-65-W	16.8	N-71-W	3.0	N-25-W	5.2	N-71-W	16.4	N-61-W	6.3	305

Table 6 shows the resultant winds based on all the observations obtained from 1926 to October, 1931. From the surface to 1,000 meters the number of observations in this group is approximately 1,700. The number decreases as the higher levels are approached until at 6 kilometers it is only slightly in excess of the number used as the basis for Tables 4 and 5. Differences in the two sets of averages appear inconsiderable and indicate, in the main, only a difference in the wind-shift level. Thus, in Table 5 the first westerly component (annual) appears at the 7-kilometer level, while in Table 6, with a somewhat greater number of observations as a basis, the north-by-west winds occur first at the height of 6 kilometers. Presumably, therefore, the average reversal level for the year over a long period is somewhat under 6 kilometers.

In October, 1931, conditions were favorable for extended upper-air observations as is generally true of the autumn period. An observation of particular interest occurred on October 21, 1931, the horizontal projection of which appears as Figure 3. Conditions on the morning of the flight were normal at the station, barometer 29.97 inches (sea level), temperature 76° F., surface wind from the southeast, velocity 4 m.p.s., and visibility 7

(good). To the north a cyclonic disturbance of moderate development, which had moved up from the western Caribbean between the seventeenth and twentieth, lowest pressure 29.7 inches, was central on the morning

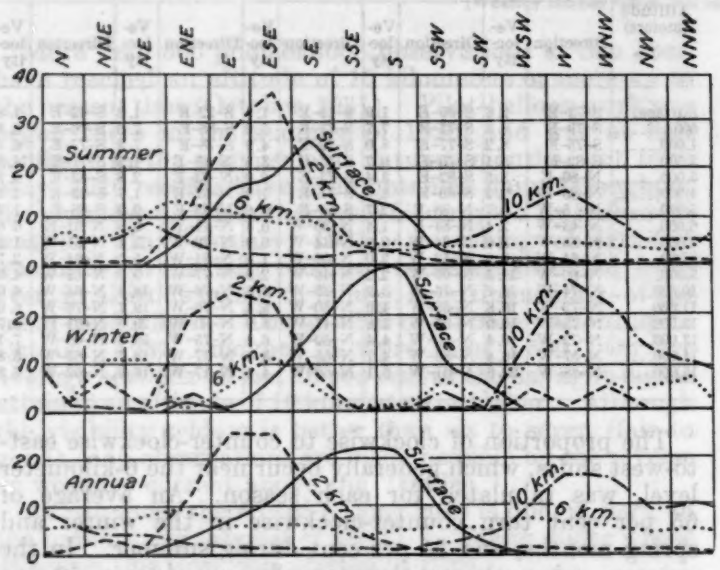

FIGURE 1.—Percentage frequency of winds from different directions at the surface 2, 6, and 10 kilometers, at San Juan, P. R.

of the 21st at latitude 29° N. and longitude 68° W. The balloon was observed to the altitude of 17.9 kilometers. The winds were southeast to south to southwest and west up to 7.6 kilometers; at 8 kilometers they shifted to north and northeast, and were light to 9.5 kilometers, then northwest. west, and southwest to 10.5 kilometers. Between 10.7 and 16.5 kilometers there was an east component—ESE. to SE.—shifting to SSW. at 16.6 kilometers, with a marked increase in velocity to 29.5 m.p.s. from SSW. at the maximum altitude of 17.9 kilometers. The southerly component presumably was due to the barometric depression to the north of the station. Three

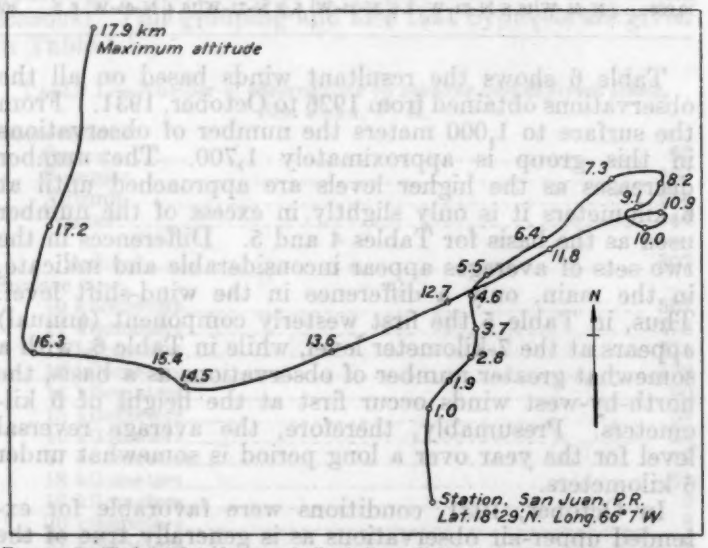

FIGURE 3.—Horizontal trajectory of pilot-balloon flight of October 21, 1931, cyclonic disturbance to the north, central in latitude 29 N., longitude 68 W. (elevation in kilometers and tenths indicated along the curve)

other flights during this same month were observed to elevations of 15 to 17 kilometers, and each showed a northerly component of the wind at its maximum altitude. (The average winds at 17 to 18 kilometers [Table 3] are N. by E.). The pressure in all three instances was generally high throughout the north and middle Atlantic.

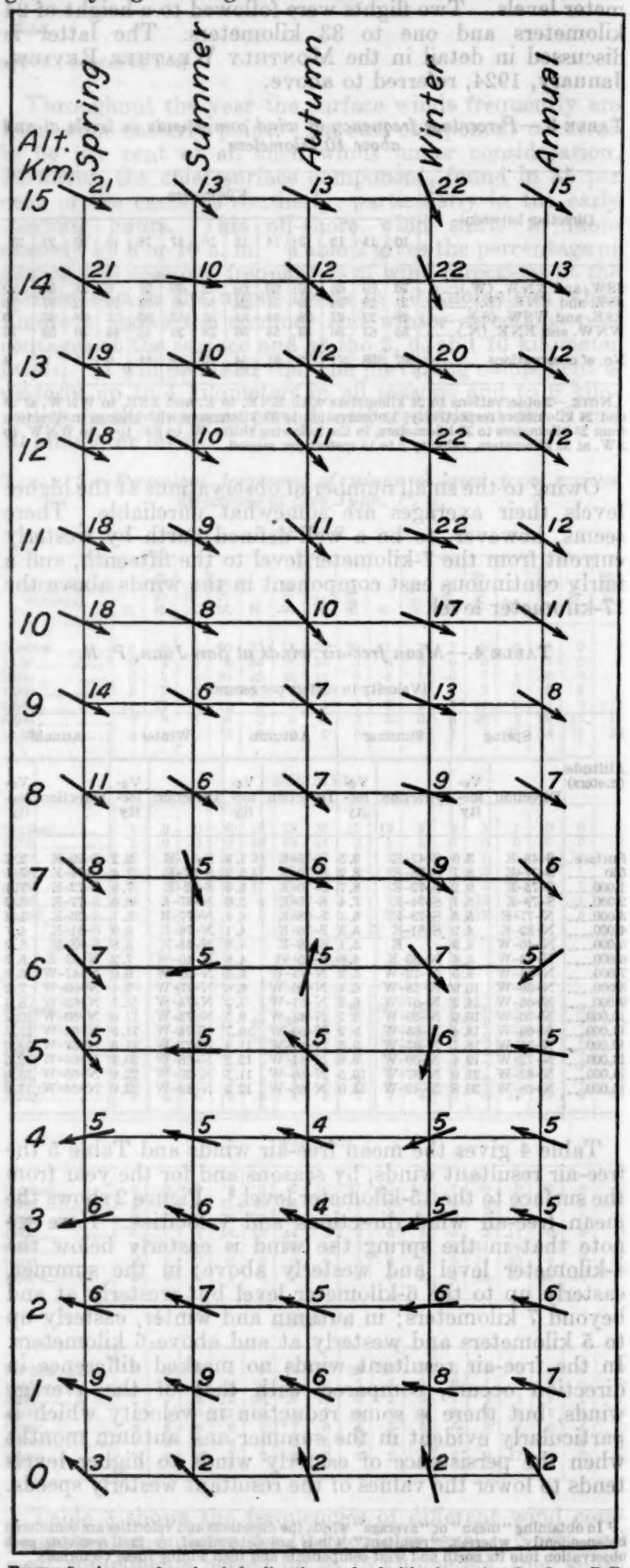

FIGURE 2.—Average free-air winds, direction, and velocities (m.p.s.) at San Juan, P. R.

SOUNDING-BALLOON OBSERVATIONS AT ROYAL CENTER, IND., DURING THE INTERNATIONAL MONTH, SEPTEMBER, 1930

By L. T. SAMUELS

[Weather Bureau, Washington, D. C., July, 1931]

In cooperation with the International Commission for the Exploration of the Upper Atmosphere the Weather Bureau conducted a series of sounding-balloon observations at the Royal Center,[1] Ind., aerological station during the international month, September, 1930. The same general program was followed as at Broken Arrow, Okla., during December, 1929, and the reader is referred to Monthly Weather Review, August, 1931, for further details regarding this. There were 36 balloons released at Royal Center and 34 (94 per cent) of the instruments returned. This is probably the highest percentage ever returned for a complete monthly series in this country.

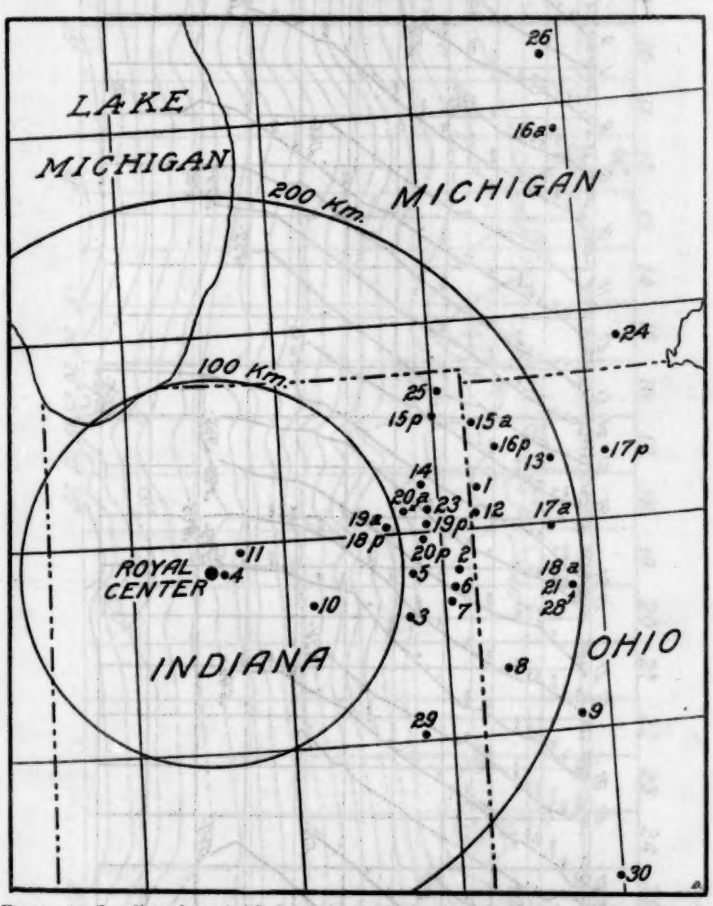

FIGURE 1.—Landing places (with dates of ascent) of meteorographs released from Royal Center, Ind., during September, 1930

The altitudes determined hypsometrically were, in general, slightly higher than those computed trigonometrically from the 2-theodolite observations, the differences averaging less than 5 per cent.

The average maximum altitude reached during the series was 12,122 meters and the extreme maximum altitude reached was 23,846 meters, on the afternoon of the sixteenth.

Following are some of the significant features of the tropopause obtained for the more recent monthly series of sounding balloon observations made in this country. (See Figure 1.)

[1] Lat. 40° 53′ N., long. 86° 29′ W.

	Date	Mean height of tropopause	Mean temperature of tropopause	Maximum height of tropopause observed	Minimum height of tropopause observed	Range in height of tropopause observed
		Meters	*° C.*	*Meters*	*Meters*	*Meters*
Royal Center, Ind.	September, 1930	12,914	−59.3	14,615	10,898	3,717
Broken Arrow, Okla.[1]	December, 1929	10,083	−54.0	12,212	7,728	4,484
Groesbeck, Tex.[2]	October, 1927	14,823	−65.5	17,467	11,695	5,772
Royal Center, Ind.[3]	May, 1926	12,011	−58.4	15,840	8,878	6,962

[1] MONTHLY WEATHER REVIEW, August, 1931, pp. 297-309.
[2] MONTHLY WEATHER REVIEW, June, 1929, pp. 231-246.
[3] MONTHLY WEATHER REVIEW, July, 1927, pp. 293-307.

The mean temperature curve for the month together with the altitude and temperature of the tropopause for the individual observations and the corresponding dates are shown in Figure 2. The maximum monthly average lapse rate and the altitude at which it occurred is given below for the more recent monthly series of sounding-balloon observations in this country.

	Date	Maximum average lapse rate	Altitude interval of occurrence
		°C/100 m.	*km.*
Royal Center, Ind.	September, 1930	0.77	9–10
Broken Arrow, Okla.[1]	December, 1929	.77	6–7
Groesbeck, Tex.[2]	October, 1927	.79	7–8
Royal Center, Ind.[3]	May, 1926	.71	7–8

[1] MONTHLY WEATHER REVIEW, August, 1931, pp. 297-309.
[2] MONTHLY WEATHER REVIEW, June, 1929, pp. 231-246.
[3] MONTHLY WEATHER REVIEW, July, 1927, pp. 293-307.

In Figure 3 are shown the individual temperature-altitude curves. The surface temperature is indicated at the bottom of each curve and the temperature at the maximum altitude at the top. The wind directions whenever observed are indicated for the standard levels adjacent to the corresponding curves.

In Figure 4 are shown the free-air isotherms for the month with the dates indicated across the top. The temperatures in the upper portion of the troposphere did not fluctuate greatly from day to day. In general, they became higher when the sea-level pressure was low and vice versa, i. e., lower when the sea-level pressure was high.

Attention is invited to the successive increase in height of the tropopause from the afternoon of the sixteenth to the afternoon of the nineteenth as shown in Table 1. As would be expected, the prevailing pressure distribution over this region changed from low to high during this period.

Figure 5 shows the mean wind velocity and direction curves for the month. The mean velocities and mean directions were determined independently of each other. It will be noted that the mean velocity reaches a maximum (38.5 m. p. s.) at 12 kilometers, i. e., just below the mean altitude of the tropopause. Above this elevation the mean wind velocity decreases at practically the same rate it increased in the troposphere.

The mean wind direction veers from southwest near the surface to slightly north of west from 2 kilometers to

10 kilometers where it backs to slightly south of west above.

Figure 6 shows the mean free-air relative humidity for the month. These data, however, must be accepted with reservation above 7 kilometers elevation on account of the uncertainty of hair hygrometers at low temperatures. It is known that the lag of hair hygrometers increases as the temperature falls below −15° C.

In Table 2 are given the tabulated data of the individual ascents. The elevation of the tropopause has been indicated in each case where it was observed.

References to previous sounding-balloon series made in this country may be found in MONTHLY WEATHER REVIEW, July, 1927, June, 1929, August, 1931.

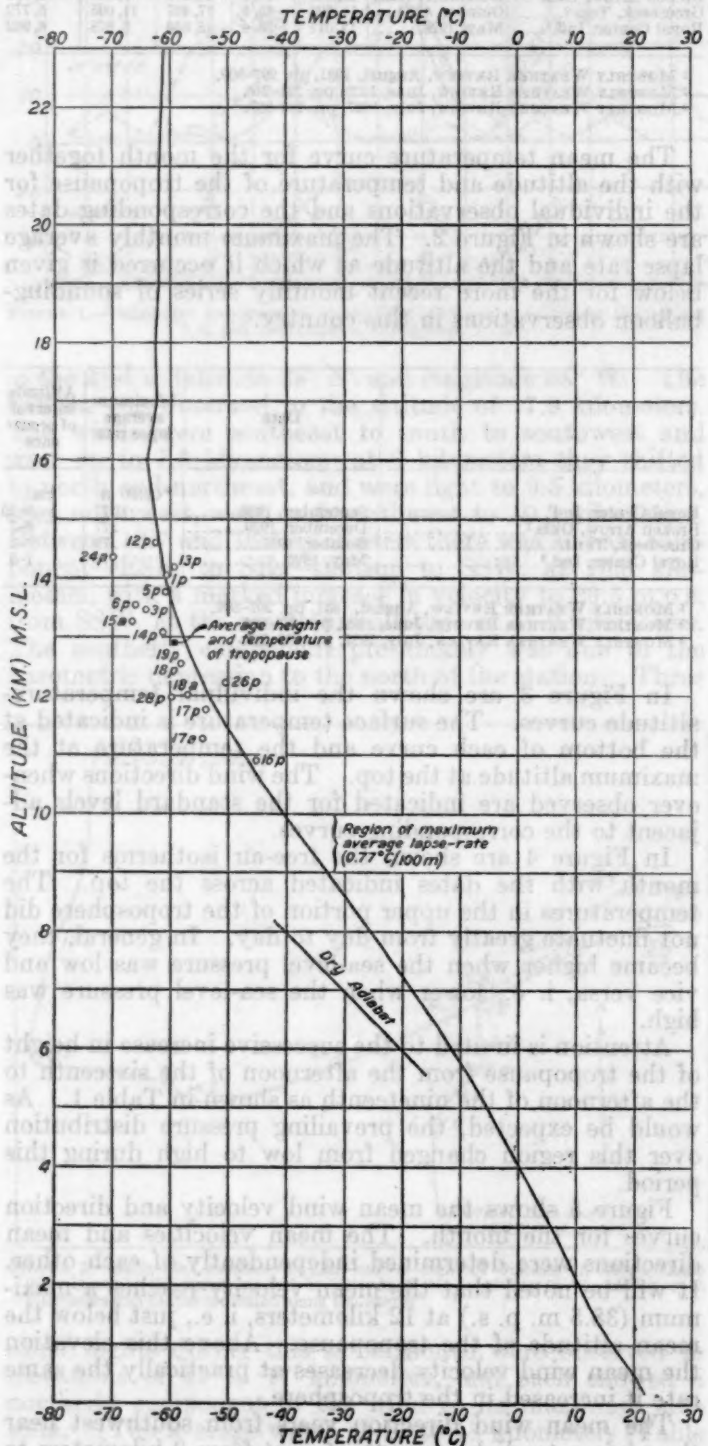

FIGURE 2.—Mean temperature curve (° C.) for September, 1930, Royal Center, Ind. Circles indicate height and temperature of tropopause with corresponding dates.

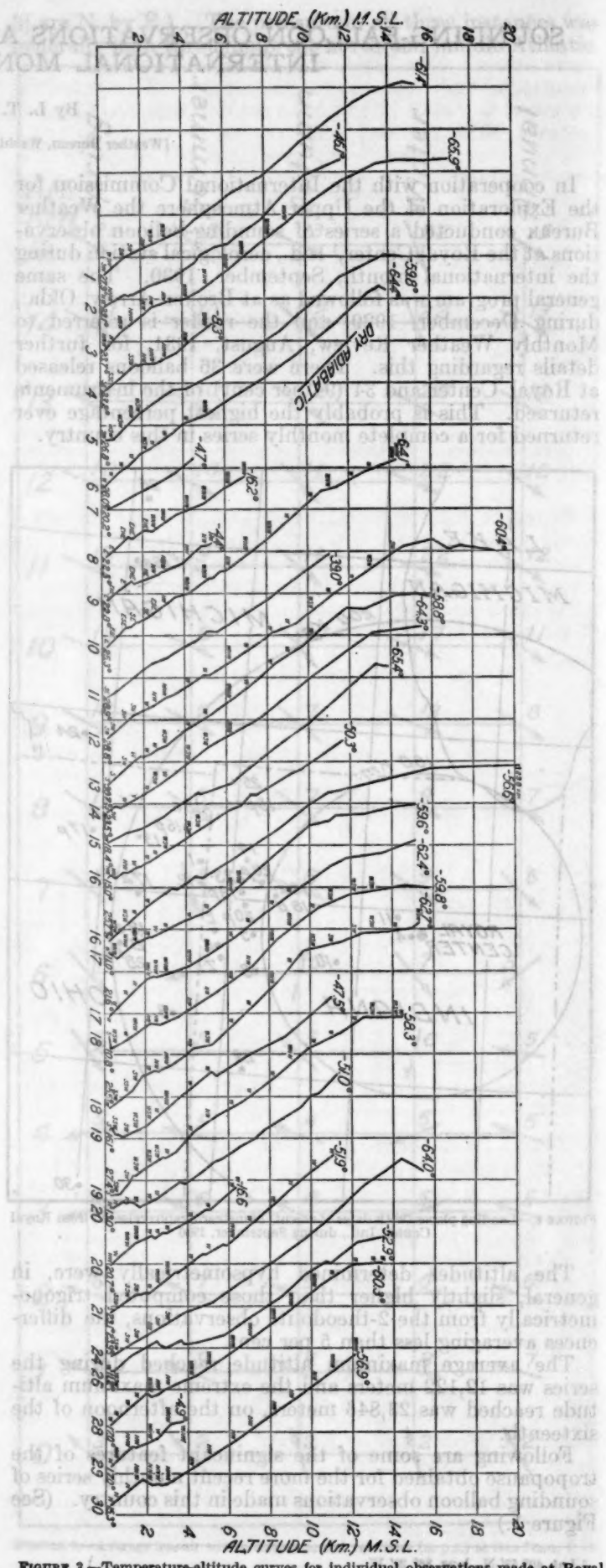

FIGURE 3.—Temperature-altitude curves for individual observations made at Royal Center, Ind., during September, 1930. Dates indicated below; figures at bottom and at top of curves indicate corresponding temperatures ° C. (Abscissa value of each square represents 20° C.)

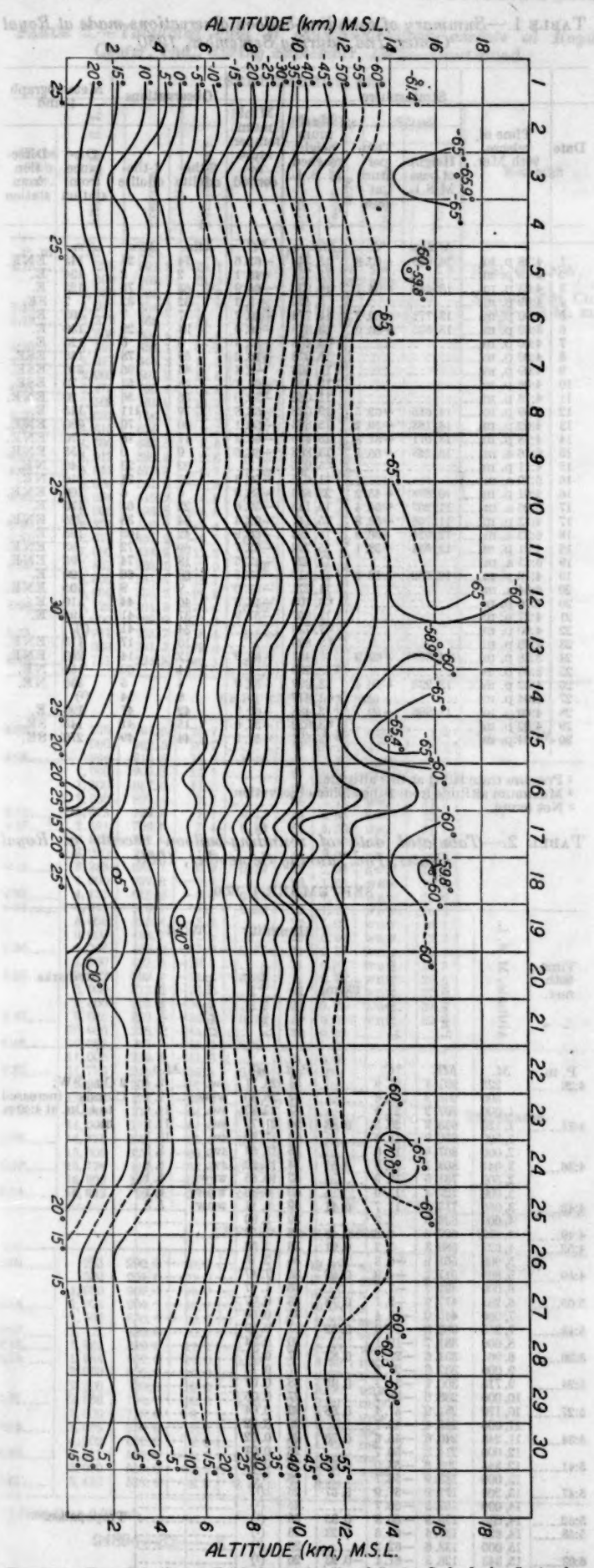

FIGURE 4.—Free-air isotherms (° C.) observed at Royal Center, Ind., during September, 1930. (Broken lines drawn between dates with missing data.)

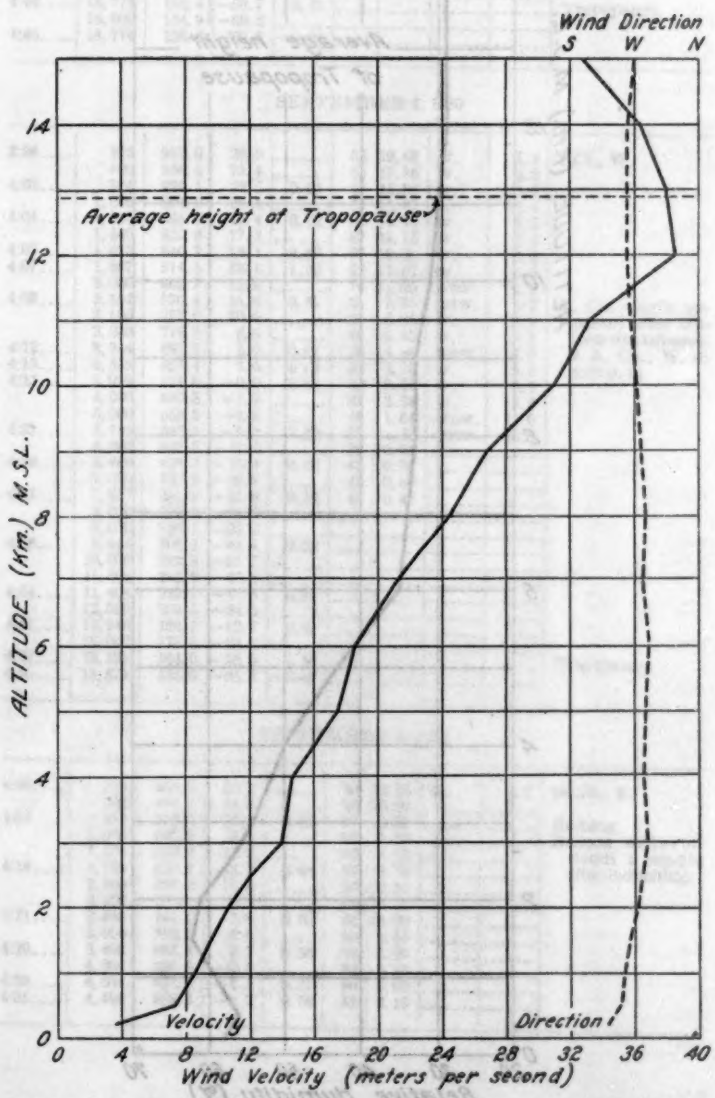

FIGURE 5.—Mean wind velocity (m. p. s.) and direction curves for September, 1930, Royal Center, Ind.

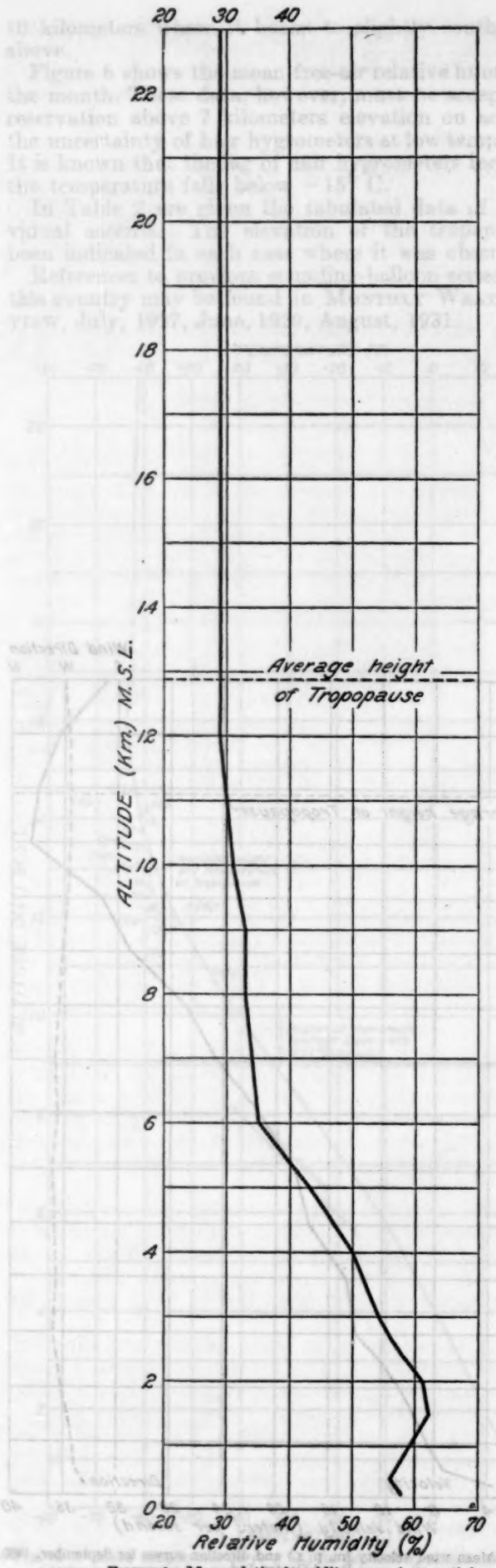

FIGURE 6.—Mean relative humidity curve (per cent) for September, 1930, Royal Center, Ind.

TABLE 1.—*Summary of sounding-balloon observations made at Royal Center, Ind., during September, 1930*

Date	Time of release, 90th Mer.	Stratosphere		Maximum height reached, M. S. L.	Minimum temperature recorded	Observations		Meteorograph found	
		Height of base M.S.L.	Temperature at base			2-theodolite	1-theodolite	Distance from station	Direction from station
		Meters	*°C.*	*Meters*	*°C.*	*Min.*	*Min.*	*Km.*	
1	4:26 p. m.	14,035	−60.8	15,343	−62.6	74	24	145	ENE.
2	4:15 p. m.			11,751	−46.1	2	2	134	E.
3	4:03 p. m.	13,449	−64.1	16,932	−65.9	63	75	125	E.
4	4:09 p. m.			5,422	−8.3	32	32	7	SE.
5	4:00 p. m.	13,771	−60.7	14,774	−60.7	7	7	105	E.
6	3:59 p. m.	13,535	−66.0	13,879	−66.0	24	29	130	E.
7	4:00 p. m.			[1] 4,498	−57.3	0	0	125	E.
8	4:00 p. m.			6,973	−16.2	59	78	165	ESE.
9	4:09 p. m.			[2] 11,508	−4.4	84	96	210	ESE.
10	4:06 p. m.			[2] 15,453	−64.1	53	53	70	ESE.
11	4:16 p. m.			11,048	−39.0	56	56	20	ENE.
12	4:09 p. m.	14,615	−62.5	19,028	−65.8	79	111	145	E.
13	4:02 p. m.	14,183	−59.2	15,893	−60.1	60	70	390	ENE.
14	4:18 p. m.	13,071	−61.3	15,495	−64.3	17	18	70	ENE.
15	6:16 a. m.	13,248	−66.5	13,888	−66.5	0	0	155	ENE.
15	4:11 p. m.			[2] 5,925		22	23	140	NE.
16	6:20 a. m.			11,675	−50.3	21	21	310	NE.
16	4:01 p. m.	10,898	−45.2	23,846	−58.0	6	6	160	ENE.
17	6:26 a. m.	11,267	−54.4	15,148	−59.6	22	65	170	E.
17	4:13 p. m.	11,766	−53.8	15,141	−62.4	34	38	225	ENE.
18	6:33 a. m.	12,024	−56.9	15,783	−60.9	42	105	195	E.
18	4:01 p. m.	12,534	−58.1	15,298	−62.7	69	72	95	ENE.
19	6:33 a. m.			11,027	−47.5	18	74	95	ENE.
19	4:10 p. m.	12,552	−58.0	[2] 15,519	−63.5	63	66	120	E.
20	6:34 a. m.			11,271	−51.0	9	9	105	ENE.
20	4:10 p. m.			[2] 6,709	−16.6	40	44	110	E.
21	4:27 p. m.			[2] 11,057	−51.9	37	41	195	E.
22	4:00 p. m.			[2] 7,733		34	41	[3]	
23	4:00 p. m.			[2] 3,825		15	17	115	ENE.
24	3:58 p. m.	14,357	−69.9	15,461	−69.9	12	14	250	ENE.
25	3:59 p. m.			[2] 13,283		64	69	155	NE.
26	4:02 p. m.	12,236	−50.4	13,397	−52.9	4	5	330	NE.
27	4:04 p. m.			[2] 1,417		8	14	[3]	
28	4:00 p. m.	11,996	−59.7	[2] 13,488	−60.3	42	47	190	E.
29	4:02 p. m.			[2] 3,923	−57.6	15	41	145	SE.
30	4:04 p. m.			[2] 13,591	−57.5	44	49	270	SE.

[1] Pressure trace failed at this altitude.
[2] Maximum altitude from 2-theodolite observation.
[3] Not found.

TABLE 2.—*Tabulated data of sounding-balloon ascents at Royal Center, Ind., during September, 1930*

SEPTEMBER 1, 1930

Time 90th mer.	Altitude, M. S. L.	Pressure	Temperature	$\frac{\Delta t}{100\,m.}$	Humidity		Wind		Remarks
					Relative	Vapor pressure	Direction	Velocity	
P. m.	*M.*	*Mb.*	*°C.*		*P. ct.*	*Mb.*		*M.p.s.*	
4:26	225	991.4	27.9		71	26.71	sw.	3.4	2 Cu., SW;
	500	955.3	23.6		77	25.30	wsw.	7.1	Clouds increased
	1,000	907.2	21.5		87	22.32	sw.	11.6	to 4 Cu. at 4:40 p.
4:31	1,120	895.2	20.5	0.83	90	21.72	sw.	11.9	m.
	1,500	856.9	18.6		83	17.80	sw.	12.7	
	2,000	807.4	16.0		75	13.64	sw.	8.8	
4:36	2,041	804.1	15.8	0.51	74	13.29	sw.	8.8	
	2,500	761.5	13.9		67	10.65	wsw.	5.1	
	3,000	727.4	11.9		60	8.36	wnw.	5.1	
4:42	3,050	713.5	11.7	0.41	59	8.11	wnw.	5.3	
	4,000	636.6	7.3		39	3.99			
4:49	4,119	627.2	6.8	0.46	36	3.56			
4:52	4,627	589.3	2.2	0.91	36	2.58			
	5,000	561.9	−0.3		36	2.15			
4:59	5,669	517.1	−4.9	0.68	36	1.47			
	6,000	494.7	−7.5		36	1.17			
5:05	6,285	477.9	−9.7	0.78	36	0.97			
	7,000	445.0	−13.4		34	0.66			
5:13	7,856	388.8	−17.9	0.52	31	0.39			
	8,000	381.7	−19.1		30	0.34			
5:20	8,961	334.6	−27.1	0.83	27	0.14			
	9,000	332.8	−27.5		27	0.13			
5:24	9,715	300.9	−34.3	0.95	28	0.07			
	10,000	288.8	−36.2		27	0.05			
5:27	10,170	281.9	−37.4	0.68	26	0.04			
	11,000	249.4	−43.7		26	0.02			
5:34	11,248	240.6	−45.6	0.76	26	0.02			
	12,000	214.3	−50.7		26	0.01			
5:41	12,345	203.6	−53.0	0.67	26	0.01			
	13,000	183.9	−56.7		26	[1]			
5:47	13,208	177.9	−57.9	0.57	26	[1]			
	14,000	157.3	−60.7		25	[1]			
5:52	14,035	155.9	−60.8	0.35	25	[1]			Tropopause.
5:58	14,821	137.4	−62.6	0.23	26	[1]			
	15,000	133.6	−62.2		26	[1]			
6:03	15,343	126.3	−61.4	−0.23	26	[1]			

[1] Less than 0.01 mb.

TABLE 2.—*Tabulated data of sounding-balloon ascents at Royal Center, Ind., during September, 1930*—Continued

SEPTEMBER 2, 1930

Time 90th mer.	Altitude, M. S. L.	Pressure	Temperature	Δt/100 m.	Humidity: Relative	Humidity: Vapor pressure	Wind: Direction	Wind: Velocity	Remarks
P. m.	*M.*	*Mb.*	°*C.*		*P.ct.*	*Mb.*		*M.p.s.*	
4:15	225	991.9	23.1	-------	85	24.04	nw.	4.0	10 St. Cu., NW.
	500	962.7	21.5	-------	84	21.55	nnw.	8.1	
	1,000	908.3	18.7	-------	82	17.70	-------	-------	Altitude of St. Cu. base—683 M. m. s. l.
4:18	1,217	884.5	17.5	0.56	81	16.21	-------	-------	
4:19	1,372	868.7	18.2	−0.45	81	16.94	-------	-------	
	1,500	856.4	17.6	-------	80	16.10	-------	-------	
4:20	1,527	853.1	17.5	0.45	80	16.01	-------	-------	
4:21	1,617	844.2	17.5	0.00	76	15.21	-------	-------	
	2,000	807.2	15.6	-------	75	13.30	-------	-------	
4:25	2,473	763.4	13.3	0.49	74	11.31	-------	-------	
	2,500	761.0	13.2	-------	73	11.08	-------	-------	
4:29	3,001	716.8	12.3	0.19	58	8.30	-------	-------	
4:33	3,515	674.1	9.7	0.51	29	3.49	-------	-------	
	4,000	634.6	6.6	-------	29	2.82	-------	-------	
4:39	4,613	589.6	2.6	0.65	29	2.13	-------	-------	
4:41	4,852	572.3	−0.7	1.38	28	1.62	-------	-------	
	5,000	561.3	−1.5	-------	30	1.62	-------	-------	
4:46	5,624	519.2	−4.8	0.71	36	1.48	-------	-------	
	6,000	494.8	−5.8	-------	32	1.21	-------	-------	
4:48	6,226	480.9	−6.4	0.27	30	1.07	-------	-------	
4:51	6,619	457.2	−9.7	0.84	38	1.02	-------	-------	
	7,000	434.9	−12.2	-------	35	0.75	-------	-------	
4:58	7,867	388.1	−17.9	0.66	27	0.34	-------	-------	
	8,000	381.4	−18.7	-------	26	0.31	-------	-------	
	9,000	333.2	−24.9	-------	21	0.14	-------	-------	
5:08	9,725	301.2	−29.4	0.62	17	0.07	-------	-------	
	10,000	289.9	−31.5	-------	17	0.06	-------	-------	
5:15	10,931	253.7	−38.4	0.75	17	0.03	-------	-------	
	11,000	251.5	−39.0	-------	17	0.02	-------	-------	
5:20	11,751	224.8	−46.1	0.94	17	0.01	-------	-------	

SEPTEMBER 3, 1930

4:03	225	994.6	23.7	-------	50	14.66	nnw.	5.4	1 Cu., NNW.
	500	962.5	20.7	-------	54	13.19	n.	7.5	
4:08	964	912.8	15.6	1.10	61	10.82	nnw.	5.5	
	1,000	909.3	15.3	-------	61	10.61	nnw.	4.9	
	1,500	857.0	11.5	-------	64	8.68	nnw.	5.6	
	2,000	807.4	7.7	-------	68	7.15	nw.	11.7	
4:13	2,073	799.5	7.1	0.77	68	6.86	nw.	12.2	
4:15	2,491	759.6	3.4	0.89	68	5.30	nw.	14.1	
	2,500	757.8	3.4	-------	68	5.30	nw.	14.2	
	3,000	712.5	1.8	-------	44	3.06	nw.	12.4	
4:18	3,283	688.7	0.9	0.32	31	2.02	nw.	11.5	
	4,000	629.8	−0.2	-------	30	1.80	wnw	10.6	
4:22	4,151	618.0	−0.4	0.15	30	1.77	wnw.	13.0	
4:24	4,849	566.1	−4.1	0.53	28	1.22	wnw.	16.8	
	5,000	555.4	−5.2	-------	27	1.07	wnw.	16.7	
	6,000	488.7	−12.5	-------	22	0.46	wnw.	12.7	
4:30	6,206	475.2	−13.9	0.72	21	0.39	wnw.	19.1	
	7,000	427.5	−20.5	-------	21	0.21	wnw.	22.8	
4:35	7,492	399.9	−24.5	0.82	21	0.14	wnw.	20.4	
	8,000	373.6	−28.3	-------	23	0.10	wnw.	27.0	
	9,000	323.3	−36.0	-------	26	0.05	wnw.	32.8	
4:40	9,025	322.5	−36.1	0.76	26	0.05	wnw.	32.6	
	10,000	278.7	−44.0	-------	22	0.02	-------	-------	
4:46	10,268	268.7	−46.2	0.81	21	0.01	-------	-------	
	11,000	239.6	−51.0	-------	21	0.01	-------	-------	
4:53	11,720	215.1	−55.8	0.66	20	(1)	-------	-------	
	12,000	205.7	−57.1	-------	20	(1)	-------	-------	
	13,000	175.7	−62.0	-------	20	(1)	-------	-------	
4:59	13,449	163.2	−64.1	0.48	20	(1)	-------	-------	Tropopause.
	14,000	149.4	−64.9	-------	20	(1)	-------	-------	
5:04	14,475	138.0	−65.5	0.14	20	(1)	-------	-------	
	15,000	126.6	−65.3	-------	20	(1)	-------	-------	
5:10	15,728	112.4	−65.1	−0.03	20	(1)	-------	-------	
	16,000	107.6	−65.3	-------	20	(1)	-------	-------	
5:14	16,932	92.3	−65.9	0.07	20	(1)	-------	-------	

SEPTEMBER 4, 1930

4:09	225	992.9	23.2	-------	45	12.81	se.	2.2	3 Cl., WSW.
	500	961.0	21.0	-------	48	11.94	sse.	2.2	
	1,000	907.4	16.9	-------	53	10.21	s.	3.0	
4:14	1,026	904.7	16.7	0.81	53	10.08	s.	2.9	
	1,500	855.1	12.8	-------	60	8.87	ssw.	3.0	
4:17	1,727	832.6	10.9	0.83	63	8.22	ssw.	2.6	
4:18	1,862	819.2	11.4	−0.37	44	5.93	wsw.	2.0	
4:19	1,984	807.3	10.6	0.66	34	4.35	nw.	2.1	
	2,000	805.7	10.6	-------	34	4.35	nw.	2.1	
	2,500	759.6	10.4	-------	29	3.66	nnw.	4.8	
4:23	2,656	744.7	10.3	0.04	28	3.51	nnw.	5.3	
	3,000	715.0	8.7	-------	25	2.81	nnw.	5.5	
4:29	3,666	658.8	5.6	0.47	19	1.73	nw.	3.7	
	4,000	632.0	2.8	-------	19	1.42	nw.	5.3	
4:35	4,511	593.3	−1.5	0.84	19	1.03	nw.	6.4	
	5,000	556.8	−5.2	-------	18	0.71	wnw.	7.2	
4:41	5,422	528.4	−8.3	0.75	18	0.55	-------	-------	

[1] Less than 0.01 mb.

TABLE 2.—*Tabulated data of sounding-balloon ascents at Royal Center, Ind., during September, 1930*—Continued

SEPTEMBER 5, 1930

Time 90th mer.	Altitude, M. S. L.	Pressure	Temperature	Δt/100 m.	Humidity: Relative	Humidity: Vapor pressure	Wind: Direction	Wind: Velocity	Remarks
P. m.	*M.*	*Mb.*	°*C.*		*P.ct.*	*Mb.*		*M.p.s.*	
4:00	225	985.9	26.8	-------	56	19.75	sw.	2.0	Few A. Cu., W., 9 St., WSW.
	500	955.0	26.4	-------	54	18.60	wsw.	6.8	
4:01	587	946.2	26.3	0.14	53	18.15	wsw.	7.1	Altitude of St. base—2,106 M. m. s. l.
	1,000	902.5	22.3	-------	60	16.16	wsw.	8.0	
	1,500	852.8	17.4	-------	69	13.72	wsw.	6.8	
4:07	1,801	822.3	14.5	0.97	74	12.22	wsw.	6.9	
	2,000	804.0	13.1	-------	-------	-------	wsw.	6.9	
	2,500	756.1	9.7	-------	-------	-------	-------	-------	
4:11	2,945	716.9	6.6	0.69	-------	-------	-------	-------	
	3,000	712.6	6.3	-------	-------	-------	-------	-------	R. B. 3:55 p. m.; E. 5:15 p. m.; [illegible] 3:50 p. m.
4:13	3,528	667.5	3.0	0.62	-------	-------	-------	-------	
	4,000	630.0	2.9	-------	-------	-------	-------	-------	
4:15	4,081	623.5	2.9	0.18	-------	-------	-------	-------	
	5,000	557.0	−1.7	-------	-------	-------	-------	-------	
4:19	5,500	522.1	−4.2	0.50	-------	-------	-------	-------	
	6,000	491.0	−7.3	-------	-------	-------	-------	-------	
4:21	6,677	448.9	−11.6	0.63	-------	-------	-------	-------	
	7,000	430.2	−13.7	-------	-------	-------	-------	-------	
	8,000	376.3	−20.3	-------	-------	-------	-------	-------	
4:25	8,650	344.9	−24.6	0.66	-------	-------	-------	-------	
	9,000	328.4	−27.6	-------	-------	-------	-------	-------	
	10,000	285.3	−36.0	-------	-------	-------	-------	-------	
4:31	10,590	262.0	−41.0	0.85	-------	-------	-------	-------	
	11,000	246.9	−44.7	-------	-------	-------	-------	-------	
4:35	11,625	224.4	−50.3	0.90	-------	-------	-------	-------	
	12,000	211.2	−52.1	-------	-------	-------	-------	-------	
	13,000	179.7	−57.0	-------	-------	-------	-------	-------	
4:42	13,771	160.4	−60.7	0.48	-------	-------	-------	-------	Tropopause.
	14,000	154.9	−60.5	-------	-------	-------	-------	-------	
4:46	14,774	136.6	−59.8	−0.09	-------	-------	-------	-------	

SEPTEMBER 6, 1930

3:59	225	987.0	28.0	-------	52	19.68	w.	1.3	8 Cl., W.
	500	956.4	25.4	-------	55	17.86	w.	2.2	
4:02	804	924.1	22.5	0.95	58	15.82	w.	3.0	
	1,000	904.0	21.1	-------	61	15.27	w.	3.4	
4:04	1,363	866.2	18.4	0.73	67	14.18	w.	4.8	
	1,500	852.0	17.2	-------	67	13.15	w.	5.4	
4:05	1,623	840.3	16.1	0.88	67	12.26	w.	5.9	
4:07	1,887	814.5	13.4	1.02	82	12.61	w.	6.3	
	2,000	802.7	12.8	-------	76	11.23	wsw.	6.2	
4:09	2,354	770.4	11.0	0.51	56	7.35	wsw.	5.2	A. Cu. clouds appeared after balloon was released.
	2,500	757.0	10.0	-------	56	6.88	w.	5.3	
	3,000	712.3	6.6	-------	56	5.45	w.	5.5	
4:12	3,244	691.7	5.0	0.67	56	4.58	wnw.	5.0	3 A. Cu., W. at 4:28 p. m.
4:13	3,535	667.4	3.0	0.69	50	3.79	w.	5.6	
4:15	3,979	631.6	−0.9	0.88	63	3.57	w.	8.5	
	4,000	630.8	−1.0	-------	63	3.55	w.	8.8	
	5,000	555.0	−4.8	-------	40	1.64	wnw.	11.9	
4:21	5,118	547.1	−5.3	0.39	37	1.45	wnw.	13.1	
	6,000	487.9	−10.8	-------	39	0.95	-------	-------	
4:26	6,489	458.3	−13.9	0.63	41	0.76	-------	-------	
	7,000	427.9	−16.9	-------	43	0.60	-------	-------	
4:31	7,857	381.8	−21.9	0.58	46	0.40	-------	-------	
	8,000	374.6	−23.0	-------	-------	-------	-------	-------	
	9,000	326.1	−30.2	-------	-------	-------	-------	-------	
4:38	9,444	306.3	−33.4	0.72	-------	-------	-------	-------	
	10,000	282.8	−37.7	-------	-------	-------	-------	-------	
	11,000	243.9	−45.4	-------	-------	-------	-------	-------	
4:44	11,406	229.7	−48.6	0.77	-------	-------	-------	-------	
	12,000	209.5	−54.0	-------	-------	-------	-------	-------	
4:51	12,946	180.5	−62.7	0.92	-------	-------	-------	-------	
	13,000	178.8	−63.0	-------	-------	-------	-------	-------	
4:53	13,535	164.0	−66.0	0.56	-------	-------	-------	-------	Tropopause.
4:54	13,879	155.0	−64.4	−0.46	-------	-------	-------	-------	

SEPTEMBER 7, 1930

4:00	225	986.8	20.2	-------	96	22.74	se.	1.7	10 Nb., E.
	500	954.1	18.8	-------	96	20.84	-------	-------	
4:06	915	910.7	16.6	0.52	97	18.33	-------	-------	Raining.
	1,000	901.2	16.1	-------	97	17.75	-------	-------	Balloon entered clouds 1 minute after launching.
	1,500	849.0	13.4	-------	97	14.92	-------	-------	
4:14	1,726	827.6	12.2	0.54	97	13.78	-------	-------	
	2,000	800.0	10.8	-------	97	12.56	-------	-------	
	2,500	754.1	8.3	-------	96	10.51	-------	-------	
4:21	2,646	741.1	7.6	0.50	96	10.02	-------	-------	
	3,000	709.5	5.6	-------	95	8.64	-------	-------	
4:29	3,498	667.8	2.7	0.58	93	6.90	-------	-------	
	4,000	626.8	−0.8	-------	90	5.15	-------	-------	
4:32	4,034	624.8	−1.1	0.71	90	5.02	-------	-------	
4:35	4,498	589.3	−4.7	0.78	52	2.15	-------	-------	

TABLE 2.—*Tabulated data of sounding-balloon ascents at Royal Center, Ind., during September, 1930*—Continued

SEPTEMBER 8, 1930

Time 90th mer.	Altitude, M. S. L.	Pressure	Temperature	$\frac{\Delta t}{100\text{ m.}}$	Humidity: Relative	Humidity: Vapor pressure	Wind: Direction	Wind: Velocity	Remarks
P. m.	*M.*	*Mb.*	°*C.*		*P.ct.*	*Mb.*		*M.p.s.*	
4:00	225	992.1	22.5	-------	50	13.64	e.	3.7	2 Cl., W.
	500	960.5	20.1	-------	52	12.24	e.	6.1	
4:08	780	930.2	17.6	0.88	55	11.07	ene.	5.4	
	1,000	905.9	15.5	-------	59	10.39	ene.	4.8	
4:05	1,300	874.8	12.6	0.96	64	9.34	ene.	4.4	
4:06	1,457	858.6	13.5	−0.57	60	9.29	ene.	3.8	
	1,500	852.8	13.3	-------	61	9.32	ene.	3.5	
4:07	1,683	835.8	12.2	0.58	65	9.24	e.	2.5	
	2,000	803.7	10.0	-------	72	8.84	ene.	1.7	
4:10	2,076	797.4	9.5	0.69	74	8.78	ne.	1.0	
4:11	2,264	779.5	9.9	−0.21	78	9.52	nw.	2.8	
	2,500	756.5	8.6	-------	78	8.71	wnw.	5.1	
	3,000	712.1	5.8	-------	79	7.28	wnw.	7.7	
4:20	3,626	660.5	2.3	0.56	80	5.77	wnw.	5.9	
	4,000	629.2	0.8	-------	68	4.40	wnw.	9.1	
4:28	4,914	562.4	−2.9	0.40	40	1.92	wnw.	17.1	
	5,000	555.2	−3.5	-------	40	1.83	wnw.	17.5	
4:35	5,912	495.1	−10.1	0.72	35	0.91	wnw.	24.1	
	6,000	489.4	−10.6	-------	34	0.84	wnw.	23.0	
4:40	6,973	430.8	−16.2	0.57	28	0.42	wnw.	23.8	

SEPTEMBER 9, 1930

4:10	225	992.1	22.8	-------	42	11.67	e.	4.0	3 Ci., W., 1 A. Cu., WNW.
	500	960.0	20.7	-------	45	10.99	ene.	5.8	
4:16	854	922.3	18.1	0.75	49	10.18	ene.	5.8	
	1,000	905.5	17.0	-------	50	9.69	e.	3.6	
4:20	1,450	859.8	13.8	0.72	55	8.68	ene.	4.1	
	1,500	853.0	14.4	-------	46	7.55	ene.	4.1	
4:21	1,553	849.3	15.1	−1.26	37	6.35	e.	4.0	
	2,000	804.1	13.4	-------	32	4.92	ne.	2.4	
	2,500	758.0	11.6	-------	27	3.69	nw.	1.2	
4:31	2,521	756.9	11.5	0.37	27	3.66	nw.	1.2	
4:33	2,718	739.3	10.7	0.41	30	3.86	n.	1.4	
4:34	2,830	729.3	10.1	0.54	28	3.46	nnw.	6.0	
	3,000	714.4	9.3	-------	31	3.63	nnw.	4.7	
4:41	3,896	640.8	5.3	0.45	49	4.37	nw.	6.6	
	4,000	632.3	4.4	-------	50	4.18	nw.	7.0	
4:48	4,827	570.8	−2.8	0.87	61	2.96	nw.	11.3	
	5,000	558.5	−3.1	-------	58	2.74	nw.	12.6	
4:50	5,136	549.0	−3.3	0.16	55	2.58	nw.	11.9	
4:51	5,357	533.8	−4.4	0.50	49	2.08	nw.	9.6	
	6,000	-------	-------	-------	-------	-------	nw.	12.8	
	7,000	-------	-------	-------	-------	-------	wnw.	15.4	
	8,000	-------	-------	-------	-------	-------	nw.	31.5	
	9,000	-------	-------	-------	-------	-------	wnw.	28.6	
	10,000	-------	-------	-------	-------	-------	wnw.	43.2	
	11,000	-------	-------	-------	-------	-------	w.	31.6	
5:34	11,508	-------	-------	-------	-------	-------	w.	36.0	

SEPTEMBER 10, 1930

4:06	225	989.4	25.3	-------	25	8.07	e.	3.1	1 Cl., WNW.
	500	958.8	22.5	-------	24	6.54	ese.	4.8	
	1,000	903.6	17.4	-------	21	4.17	ese.	5.6	
4:09	1,099	894.0	16.4	1.02	21	3.92	se.	5.8	
4:10	1,418	861.0	15.5	0.28	17	2.99	se.	5.6	
	1,500	852.7	14.9	-------	17	2.88	se.	5.3	
4:11	1,648	837.8	13.7	0.78	17	2.67	se.	4.7	
4:12	1,763	826.4	13.6	0.09	17	2.65	se.	3.8	
	2,000	801.9	12.3	-------	16	2.29	se.	2.5	
4:13	2,265	778.3	10.9	0.54	14	1.83	se.	1.4	Pressure record inaccurate; altitudes determined from 2-theodolite observation; pressures computed from altitudes and temperatures.
	2,500	754.2	9.2	-------	16	1.86	ese.	0.7	
	3,000	710.0	5.5	-------	20	1.81	nw.	0.5	
4:18	3,553	665.1	1.4	0.74	25	1.69	w.	2.8	
	4,000	629.3	0.2	-------	24	1.49	wnw.	4.7	
4:20	4,169	615.9	−0.2	0.26	23	1.38	wnw.	4.6	
4:21	4,511	590.1	−2.5	0.67	25	1.24	wnw.	6.0	
4:22	4,585	584.6	−2.1	−0.54	27	1.39	wnw.	6.8	
	5,000	551.0	−5.6	-------	-------	-------	wnw.	8.0	
4:23	5,171	542.6	−7.1	0.85	-------	-------	wnw.	8.5	
4:24	5,404	526.6	−7.6	0.21	-------	-------	wnw.	10.2	
4:25	5,729	504.9	−10.5	0.89	-------	-------	wnw.	11.6	
4:26	5,964	489.7	−10.7	0.09	-------	-------	nw.	11.9	
	6,000	487.0	−10.9	-------	-------	-------	nw.	11.9	
4:28	6,431	460.7	−13.9	0.68	-------	-------	nw.	11.7	
	7,000	426.9	−18.2	-------	-------	-------	wnw.	11.5	
4:33	7,829	381.9	−24.4	0.75	-------	-------	wnw.	12.5	
	8,000	372.0	−25.9	-------	-------	-------	wnw.	11.9	
	9,000	323.7	−34.5	-------	-------	-------	w.	15.8	
4:39	9,435	304.5	−38.2	0.86	-------	-------	w.	18.4	
	10,000	280.0	−43.1	-------	-------	-------	w.	20.2	
4:43	10,639	254.7	−48.9	0.89	-------	-------	wnw.	21.0	
	11,000	241.2	−49.7	-------	-------	-------	wnw.	24.7	
4:45	11,303	230.2	−50.3	0.21	-------	-------	wnw.	25.6	
	12,000	207.2	−54.0	-------	-------	-------	w.	27.4	
4:50	12,817	181.9	−58.4	0.54	-------	-------	w.	27.5	
	13,000	176.9	−59.1	-------	-------	-------	w.	28.0	
	14,000	150.2	−62.8	-------	-------	-------	wnw.	23.4	
4:55	14,341	142.4	−64.1	0.37	-------	-------	wnw.	24.8	
	15,000	-------	-------	-------	-------	-------	wnw.	30.3	
4:59	15,453	-------	-------	-------	-------	-------	wnw.	20.0	

TABLE 2.—*Tabulated data of sounding-balloon ascents at Royal Center, Ind., during September, 1930*—Continued

SEPTEMBER 11, 1930

Time 90th mer.	Altitude, M. S. L.	Pressure	Temperature	$\frac{\Delta t}{100\text{ m.}}$	Humidity: Relative	Humidity: Vapor pressure	Wind: Direction	Wind: Velocity	Remarks
P. m.	*M.*	*Mb.*	°*C.*		*P.ct.*	*Mb.*		*M.p.s.*	
4:16	225	985.4	28.9	-------	50	19.94	se.	1.6	1 Ci., W., 7 Cl. St., W.
	500	955.5	27.5	-------	48	17.64	-------	-------	
4:17	511	954.3	27.4	0.52	48	17.53	-------	-------	
	1,000	903.1	23.6	-------	54	15.74	-------	-------	
	1,500	853.0	19.8	-------	61	14.10	-------	-------	
4:23	1,995	804.4	15.8	0.78	67	12.03	-------	-------	
4:25	2,412	765.7	13.2	0.62	47	7.13	-------	-------	
	2,500	757.5	12.8	-------	47	6.95	-------	-------	
4:26	2,710	739.0	12.0	0.40	46	6.45	-------	-------	
4:27	2,954	717.7	11.2	0.33	41	5.45	-------	-------	
	3,000	712.5	11.0	-------	42	5.51	-------	-------	
4:28	3,144	701.5	10.4	0.42	44	5.55	-------	-------	
4:31	3,772	650.3	6.6	0.61	50	4.87	-------	-------	
4:32	3,942	636.9	5.6	0.59	55	5.00	-------	-------	
	4,000	631.7	5.3	-------	54	4.81	-------	-------	
4:33	4,066	627.4	5.0	0.48	53	4.62	-------	-------	
4:35	4,621	586.0	2.0	0.54	64	4.51	-------	-------	
	5,000	559.0	−1.1	-------	66	3.68	-------	-------	
4:37	5,093	552.5	−1.9	0.83	66	3.45	-------	-------	
4:38	5,536	522.7	−1.6	−0.07	41	2.20	-------	-------	
	6,000	492.9	−4.5	-------	38	1.60	-------	-------	
	7,000	432.4	−10.6	-------	32	0.79	-------	-------	
4:48	7,925	384.1	−16.4	0.62	26	0.38	-------	-------	
	8,000	379.5	−17.0	-------	27	0.38	-------	-------	
	9,000	332.4	−24.4	-------	34	0.23	-------	-------	
4:54	9,442	312.7	−27.7	0.74	38	0.19	-------	-------	
	10,000	289.2	−31.6	-------	38	0.12	-------	-------	
	11,000	250.1	−38.6	-------	39	0.06	-------	-------	
4:59	11,048	248.9	−39.0	0.70	39	0.06	-------	-------	

SEPTEMBER 12, 1930

4:09	225	981.1	28.8	-------	61	24.18	sw.	1.4	1 Cu SW.
	500	950.0	26.5	-------	-------	-------	sw.	2.8	
4:11	827	916.5	23.7	0.85	-------	-------	sw.	4.0	
	1,000	897.0	22.2	-------	-------	-------	sw.	4.2	
	1,500	847.5	17.9	-------	-------	-------	sw.	3.8	
4:14	1,512	846.8	17.8	0.86	-------	-------	sw.	3.8	
	2,000	799.5	15.5	-------	-------	-------	w.	2.3	
4:19	2,408	762.1	13.5	0.48	-------	-------	nw.	3.3	
	2,500	752.8	12.9	-------	-------	-------	nw.	3.3	
	3,000	708.2	9.8	-------	-------	-------	nnw.	1.5	
4:22	3,071	704.0	9.4	0.62	-------	-------	nnw.	1.6	
4:24	3,486	669.6	8.1	0.31	-------	-------	wnw.	2.4	
	4,000	629.5	4.7	-------	-------	-------	w.	5.5	
4:30	4,930	560.6	−1.4	0.66	-------	-------	w.	6.5	
	5,000	555.0	−1.3	-------	-------	-------	w.	5.5	
4:32	5,194	542.3	−1.2	−0.08	-------	-------	w.	5.4	
	6,000	489.3	−6.3	-------	-------	-------	wnw.	6.2	
4:37	6,535	457.2	−9.7	0.63	-------	-------	w.	10.3	
	7,000	429.9	−12.8	-------	-------	-------	w.	12.6	
4:42	7,926	380.7	−18.9	0.66	-------	-------	w.	12.5	
	8,000	376.8	−19.5	-------	-------	-------	w.	12.2	
4:44	8,265	363.7	−21.7	0.83	-------	-------	w.	11.3	
4:45	8,351	359.5	−21.5	−0.23	-------	-------	w.	11.0	
	9,000	328.5	−24.1	-------	-------	-------	w.	14.2	
4:48	9,383	312.2	−25.6	0.40	-------	-------	wsw.	12.6	
	10,000	286.5	−30.5	-------	-------	-------	wsw.	16.8	
	11,000	248.7	−38.5	-------	-------	-------	w.	24.0	
4:54	11,104	244.7	−39.3	0.80	-------	-------	wsw.	23.8	
	12,000	214.4	−45.0	-------	-------	-------	w.	23.5	
4:59	12,574	196.7	−48.6	0.63	-------	-------	wsw.	21.2	
	13,000	184.0	−51.6	-------	-------	-------	wsw.	23.0	
	14,000	157.5	−58.5	-------	-------	-------	sw.	22.5	
5:04	14,186	153.1	−59.8	0.69	-------	-------	sw.	20.0	
5:06	14,615	142.9	−62.5	0.63	-------	-------	-------	-------	Tropopause.
	15,000	134.3	−63.4	-------	-------	-------	-------	-------	
	16,000	114.2	−65.6	-------	-------	-------	-------	-------	
5:12	16,078	112.6	−65.8	0.23	-------	-------	-------	-------	
5:17	16,798	100.2	−61.1	−0.65	-------	-------	-------	-------	
	17,000	96.8	−61.7	-------	-------	-------	-------	-------	
5:18	17,409	90.8	−62.9	0.29	-------	-------	-------	-------	
	18,000	82.3	−62.0	-------	-------	-------	-------	-------	
	19,000	70.1	−60.4	-------	-------	-------	-------	-------	
5:24	19,028	70.0	−60.4	−0.15	-------	-------	-------	-------	

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4:02	225	981.2	30.7	-------	47	20.78	s.	3.6	Few Ci. St., W.
	500	951.8	28.3	-------	51	19.64	s.	4.4	
	1,000	899.5	24.0	-------	58	17.32	sw.	5.2	
	1,500	849.0	19.7	-------	66	15.15	w.	6.2	
4:07	1,596	839.3	18.9	0.86	67	14.64	w.	6.3	
4:08	1,832	816.6	17.3	0.68	74	14.62	w.	6.8	
4:09	1,940	806.3	17.5	−0.19	54	10.81	w.	7.1	
	2,000	801.0	17.3	-------	53	10.47	w.	7.2	
4:11	2,256	777.0	16.3	0.38	50	9.27	w.	7.8	
	2,500	756.0	14.9	-------	54	9.15	w.	8.3	
4:14	2,665	740.4	14.0	0.56	57	9.11	w.	7.7	
	3,000	711.1	12.5	-------	45	6.52	wsw.	7.5	
4:16	3,079	704.7	12.2	0.43	42	5.97	wsw.	7.8	
4:20	3,741	650.8	7.3	0.74	41	4.19	wsw.	9.4	

TABLE 2.—*Tabulated data of sounding-balloon ascents at Royal Center, Ind., during September, 1930*—Continued

SEPTEMBER 13, 1930—Continued

Time 90th mer.	Altitude, M. S. L.	Pressure	Temperature	$\frac{\Delta t}{100\text{ m.}}$	Humidity: Relative	Humidity: Vapor pressure	Wind: Direction	Wind: Velocity	Remarks
P. m.	*M.*	*Mb.*	°*C.*		*P.ct.*	*Mb.*		*M.b.s.*	
4:21	3,935	635.6	5.2	1.08	48	4.24	w.	9.5	
	4,000	630.6	4.8	-------	47	4.04	w.	9.5	
	5,000	557.2	−1.0	-------	27	1.52	w.	14.2	
4:30	5,278	538.0	−2.6	0.58	22	1.08	w.	14.5	
	6,000	490.9	−7.7	-------	19	0.61	wnw.	17.7	
4:37	6,325	470.7	−10.0	0.71	18	0.47	w.	15.3	
	7,000	430.8	−15.1	-------	-------	-------	w.	17.0	
4:43	7,504	403.0	−18.9	0.75	-------	-------	w.	18.1	
	8,000	377.0	−23.3	-------	-------	-------	w.	20.0	
4:50	8,386	357.3	−26.7	0.88	-------	-------	w.	20.4	
	9,000	328.3	−31.2	-------	-------	-------	w.	26.8	
4:57	9,497	305.6	−34.9	0.74	-------	-------	w.	22.2	
	10,000	294.4	−38.8	-------	-------	-------	w.	23.0	
5:05	10,828	251.6	−45.2	0.77	-------	-------	-------	-------	
	11,000	245.2	−46.6	-------	-------	-------	-------	-------	
5:12	11,855	215.2	−53.3	0.79	-------	-------	-------	-------	
	12,000	210.8	−53.2	-------	-------	-------	-------	-------	
5:18	12,740	187.6	−52.7	−0.07	-------	-------	-------	-------	
	13,000	180.2	−53.9	-------	-------	-------	-------	-------	
	14,000	154.0	−58.4	-------	-------	-------	-------	-------	
5:25	14,183	149.6	−59.2	0.45	-------	-------	-------	-------	Tropopause.
	15,000	131.2	−59.9	-------	-------	-------	-------	-------	
5:31	15,165	127.9	−60.1	0.09	-------	-------	-------	-------	
5:38	15,893	113.9	−58.9	−0.16	-------	-------	-------	-------	

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4:18	225	981.5	23.5	-------	72	20.87	s.	2.4	5 Cl. St., W. 2 A. St., WSW.
	500	950.4	21.7	-------	-------	-------	sw.	7.5	2 St. Cu., W.
4:19	607	939.2	21.0	0.65	-------	-------	sw.	8.2	
4:20	849	913.5	21.7	−0.29	-------	-------	wsw.	10.8	
	1,000	897.5	20.9	-------	-------	-------	w.	12.0	
	1,500	846.8	18.1	-------	-------	-------	w.	19.6	
	2,000	799.0	15.3	-------	-------	-------	w.	12.4	
4:25	2,259	774.8	13.9	0.55	-------	-------	wsw.	12.2	
	2,500	752.8	12.2	-------	-------	-------	wsw.	13.0	
	3,000	705.0	8.8	-------	-------	-------	w.	18.0	
4:29	3,459	670.8	5.6	0.69	-------	-------	wsw.	23.6	
	4,000	627.4	1.4	-------	-------	-------	wsw.	26.6	
	5,000	552.9	−6.2	-------	-------	-------	wsw.	29.2	
4:35	5,060	549.3	−6.7	0.77	-------	-------	wsw.	29.1	Altitude of A. St. base, 5,150 M. m. s. l.
	6,000	485.0	−11.9	-------	-------	-------	-------	-------	
	7,000	425.0	−17.4	-------	-------	-------	-------	-------	
4:42	7,690	388.6	−21.2	0.55	-------	-------	-------	-------	
	8,000	372.1	−23.6	-------	-------	-------	-------	-------	
	9,000	324.2	−31.4	-------	-------	-------	-------	-------	
	10,000	280.9	−39.2	-------	-------	-------	-------	-------	
4:48	10,229	271.8	−41.0	0.78	-------	-------	-------	-------	
	11,000	241.2	−46.5	-------	-------	-------	-------	-------	
	12,000	207.0	−53.6	-------	-------	-------	-------	-------	
	13,000	177.3	−60.8	-------	-------	-------	-------	-------	
4:57	13,071	175.7	−61.3	0.71	-------	-------	-------	-------	Tropopause.
	14,000	151.9	−62.5	-------	-------	-------	-------	-------	
	15,000	129.3	−63.7	-------	-------	-------	-------	-------	
5:05	15,495	118.7	−64.3	0.12	-------	-------	-------	-------	

SEPTEMBER 15, 1930

A. m.									
6:16	225	984.1	18.4	-------	99	20.96	sw.	2.4	10 St., SW. Misting. Balloon entered clouds 40 seconds after launching.
	500	952.7	17.0	-------	98	18.99	-------	-------	
	1,000	899.2	14.4	-------	96	15.75	-------	-------	
6:19	1,113	886.8	13.8	0.52	96	15.15	-------	-------	
	1,500	847.0	12.6	-------	78	11.38	-------	-------	
6:22	1,878	809.5	11.5	0.30	60	8.14	-------	-------	
	2,000	798.0	10.9	-------	61	7.95	-------	-------	
	2,500	751.0	8.3	-------	64	7.01	-------	-------	
6:26	2,880	717.4	6.4	0.51	66	6.34	-------	-------	
	3,000	707.1	5.5	-------	73	6.59	-------	-------	
6:27	3,420	671.4	2.2	0.78	98	7.02	-------	-------	
	4,000	623.8	−1.4	-------	99	5.39	-------	-------	
6:31	4,610	578.5	−5.1	0.61	100	4.00	-------	-------	
6:32	4,758	567.8	−4.8	−0.20	88	3.61	-------	-------	
	5,000	550.0	−5.3	-------	67	2.63	-------	-------	
6:33	5,077	545.1	−5.5	0.22	60	2.32	-------	-------	
	6,000	484.1	−9.0	-------	47	1.34	-------	-------	
6:40	6,227	470.3	−9.8	0.37	44	1.17	-------	-------	
6:41	6,709	441.6	−14.2	0.91	53	0.95	-------	-------	
	7,000	424.3	−16.4	-------	56	0.82	-------	-------	
	8,000	371.1	−24.0	-------	65	0.46	-------	-------	
6:48	8,262	358.3	−26.0	0.76	68	0.39	-------	-------	
	9,000	323.2	−31.2	-------	61	0.21	-------	-------	
6:56	9,961	281.9	−38.0	0.71	52	0.08	-------	-------	
	10,000	280.4	−38.3	-------	52	0.08	-------	-------	
	11,000	242.1	−46.8	-------	45	0.03	-------	-------	
7:02	11,162	236.0	−48.2	0.85	44	0.02	-------	-------	
	12,000	207.9	−55.7	-------	43	0.01	-------	-------	

TABLE 2.—*Tabulated data of sounding-balloon ascents at Royal Center, Ind., during September, 1930*—Continued

SEPTEMBER 15, 1930—Continued

Time 90th mer.	Altitude, M. S. L.	Pressure	Temperature	$\frac{\Delta t}{100\text{ m.}}$	Humidity: Relative	Humidity: Vapor pressure	Wind: Direction	Wind: Velocity	Remarks
A. m.	*M.*	*Mb.*	°*C.*		*P.ct.*	*Mb.*		*M.p.s.*	
7:08	12,472	192.5	−60.0	0.90	42	(1)	-------	-------	
	13,000	177.1	−64.4	-------	42	(1)	-------	-------	
7:11	13,248	169.7	−66.5	0.84	42	(1)	-------	-------	Tropopause.
7:13	13,714	157.2	−65.4	−0.24	42	(1)	-------	-------	
7:14	13,888	152.8	−65.4	0.00	43	(1)	-------	-------	

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6:20	225	983.8	15.0	-------	98	16.72	nw.	0.4	5 A. St., SW., 4 A. Cu., SW.
6:21	312	973.8	13.9	1.26	82	13.03	nw.	3.4	
	500	953.4	15.1	-------	66	11.33	nw.	3.4	
6:22	570	944.5	15.5	−0.62	60	10.57	nw.	3.6	
6:24	941	903.9	12.9	0.70	64	9.52	nnw.	3.4	
	1,000	898.6	12.9	-------	60	8.93	nw.	3.5	
6:25	1,189	877.6	12.9	0.00	48	7.14	nw.	4.1	
	1,500	845.6	11.0	-------	67	8.23	w.	7.4	
6:27	1,637	831.8	10.2	0.60	75	9.33	w.	8.0	Altitude of A. Cu. base, 4,765 M. m. s. l.
6:28	1,800	815.7	10.0	0.12	68	8.35	w.	7.6	
	2,000	795.9	8.6	-------	72	8.04	w.	5.2	
6:29	2,026	793.7	8.4	0.71	73	8.04	w.	5.1	
6:31	2,272	770.4	7.5	0.37	56	5.81	w.	5.1	
	2,500	748.9	6.1	-------	66	6.21	w.	5.0	
	3,000	704.7	2.9	-------	87	6.54	wsw.	9.2	
6:35	3,205	687.2	1.6	0.63	96	6.59	wsw.	9.6	
6:37	3,543	658.8	−0.2	0.53	90	5.41	w.	8.3	
	4,000	622.0	−3.4	-------	95	4.38	wsw.	10.8	
6:41	4,436	588.6	−6.5	0.71	100	3.55	wsw.	13.8	
	5,000	547.8	−10.1	-------	84	2.18	-------	-------	
	6,000	479.9	−16.4	-------	56	0.82	-------	-------	
6:49	6,088	474.6	−16.9	0.63	54	0.76	-------	-------	
6:50	6,648	440.4	−19.0	0.38	61	0.70	-------	-------	
	7,000	419.4	−22.8	-------	56	0.45	-------	-------	
6:53	7,108	413.8	−24.0	1.09	54	0.38	-------	-------	
6:55	7,408	397.2	−24.0	0.00	54	0.38	-------	-------	
	8,000	365.7	−27.6	-------	58	0.29	-------	-------	
	9,000	318.0	−33.7	-------	65	0.17	-------	-------	
7:02	9,087	314.2	−34.2	0.61	66	0.16	-------	-------	
7:05	9,544	294.3	−36.0	0.39	54	0.11	-------	-------	
	10,000	275.6	−39.1	-------	54	0.08	-------	-------	
	11,000	238.0	−45.8	-------	54	0.04	-------	-------	
7:14	11,675	214.6	−50.3	0.67	54	0.02	-------	-------	

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P. m.									
4:01	225	981.3	25.4	-------	46	14.94	sw.	5.5	7 Cu., W.
	500	949.4	23.0	-------	40	13.77	wsw.	10.9	
	1,000	895.9	18.6	-------	54	11.58	wsw.	13.2	
4:05	1,278	868.7	16.2	0.87	57	10.50	w.	15.1	
	1,500	844.8	14.2	-------	64	10.37	w.	15.8	
	2,000	795.2	9.7	-------	79	9.50	-------	-------	
4:07	2,105	787.1	8.7	0.91	82	9.22	-------	-------	
	2,500	747.6	6.0	-------	87	8.13	-------	-------	
	3,000	703.8	2.5	-------	94	6.87	-------	-------	
4:11	3,289	680.9	0.5	0.69	98	6.20	-------	-------	
4:13	3,583	656.4	0.7	−0.07	53	3.40	-------	-------	
	4,000	622.6	−2.2	-------	52	2.65	-------	-------	
4:15	4,453	588.3	−5.3	0.69	50	1.96	-------	-------	
4:16	4,819	561.6	−4.8	−0.14	37	1.52	-------	-------	
	5,000	548.9	−5.9	-------	36	1.35	-------	-------	
	6,000	483.2	−12.1	-------	28	0.61	-------	-------	
4:22	6,400	454.2	−14.9	0.61	24	0.41	-------	-------	
	7,000	423.2	−18.4	-------	22	0.27	-------	-------	
	8,000	369.4	−24.9	-------	19	0.12	-------	-------	
4:28	8,377	350.5	−27.3	0.65	18	0.09	-------	-------	
	9,000	321.0	−32.1	-------	15	0.05	-------	-------	
4:33	9,860	284.0	−38.8	0.78	12	0.02	-------	-------	
	10,000	278.1	−39.7	-------	12	0.02	-------	-------	
4:36	10,898	243.7	−45.2	0.62	14	0.01	-------	-------	Tropopause.
	11,000	238.9	−45.4	-------	14	0.01	-------	-------	
4:38	11,469	223.7	−46.2	0.18	14	0.01	-------	-------	
	12,000	205.3	−47.5	-------	14	0.01	-------	-------	
	13,000	176.6	−50.0	-------	14	0.01	-------	-------	
4:45	13,554	163.0	−51.3	0.24	14	(1)	-------	-------	
	14,000	151.9	−52.3	-------	14	(1)	-------	-------	
	15,000	130.6	−54.7	-------	14	(1)	-------	-------	
4:50	15,909	113.1	−56.8	0.23	14	(1)	-------	-------	
	16,000	111.7	−56.8	-------	14	(1)	-------	-------	
	17,000	95.4	−57.3	-------	14	(1)	-------	-------	
4:57	18,005	81.3	−57.7	0.04	14	(1)	-------	-------	
	19,000	69.8	−57.8	-------	14	(1)	-------	-------	
	20,000	59.8	−57.9	-------	14	(1)	-------	-------	
5:02	20,447	55.3	−58.0	0.01	14	(1)	-------	-------	
	21,000	50.8	−57.8	-------	14	(1)	-------	-------	
	22,000	43.2	−57.4	-------	14	(1)	-------	-------	
	23,000	37.0	−56.9	-------	14	(1)	-------	-------	
5:07	23,846	32.4	−56.6	−0.04	14	(1)	-------	-------	

[1] Less than 0.01 mb.

TABLE 2.—*Tabulated data of sounding-balloon ascents at Royal Center, Ind., during September, 1930*—Continued

SEPTEMBER 17, 1930

Time 90th mer.	Altitude, M. S. L.	Pressure	Temperature	$\frac{\Delta t}{100\text{ m.}}$	Humidity: Relative	Humidity: Vapor pressure	Wind: Direction	Wind: Velocity	Remarks
A. m.	*M.*	*Mb.*	°*C.*		*P.ct.*	*Mb.*		*M.p.s.*	
6:26	225	990.2	11.0	-------	78	10.24	w.	2.0	Cloudless.
	500	957.6	13.1	-------	62	9.35	wnw.	10.4	
6:27	615	945.3	14.0	−0.77	56	8.95	wnw.	10.9	
	1,000	902.7	10.9	-------	59	7.69	wnw.	11.6	
	1,500	849.8	6.8	-------	62	6.13	wnw.	13.1	
6:30	1,588	840.8	6.1	0.81	63	5.93	wnw.	13.9	
6:31	1,756	823.8	5.6	0.30	53	4.82	wnw.	15.3	
	2,000	799.8	4.5	-------	51	4.29	w.	17.4	
6:32	2,171	782.8	3.7	0.46	49	3.90	w.	18.0	
6:33	2,347	766.1	3.7	0.00	44	3.50	w.	18.5	
	2,500	751.9	3.0	-------	43	3.26	w.	18.4	
	3,000	702.5	0.6	-------	38	2.42	w.	19.7	
6:38	3,949	627.3	−4.0	0.48	30	1.32	w.	19.7	
	4,000	622.4	−4.2	-------	30	1.29	w.	19.9	
	5,000	548.7	−8.2	-------	29	0.89	w.	23.8	
6:41	5,036	546.0	−8.3	0.40	29	0.88	w.	24.2	
	6,000	480.8	−15.7	-------	28	0.44	wnw.	32.2	
6:46	6,254	465.5	−17.7	0.77	28	0.36	wnw.	29.2	
	7,000	420.7	−24.2	-------	27	0.19	-------	-------	
6:50	7,433	396.5	−28.0	0.87	27	0.13	-------	-------	
	8,000	366.6	−32.7	-------	27	0.08	-------	-------	
6:54	8,898	321.8	−40.2	0.83	27	0.03	-------	-------	
	9,000	317.1	−41.1	-------	27	0.03	-------	-------	
	10,000	272.9	−49.7	-------	26	0.01	-------	-------	
6:57	10,016	272.3	−49.8	0.86	26	0.01	-------	-------	
7:01	10,975	235.1	−51.9	0.22	25	0.01	-------	-------	
	11,000	234.3	−52.1	-------	25	0.01	-------	-------	
7:02	11,267	224.7	−54.4	0.86	25	0.01	-------	-------	Tropopause.
	12,000	200.2	−54.9	-------	23	(1)	-------	-------	
7:09	12,663	180.7	−55.4	0.07	22	(1)	-------	-------	
	13,000	171.4	−56.1	-------	22	(1)	-------	-------	
	14,000	146.8	−58.3	-------	22	(1)	-------	-------	
7:16	14,075	144.7	−58.5	0.22	22	(1)	-------	-------	
	15,000	124.7	−59.4	-------	21	(1)	-------	-------	
7:23	15,148	122.0	−59.6	0.10	21	(1)	-------	-------	

SEPTEMBER 17, 1930

P. m.									
4:14	225	990.0	21.6	-------	28	7.23	w.	6.7	1 Cl., W.
	500	958.1	18.8	-------	28	6.08	w.	10.2	
4:16	751	931.0	16.2	1.03	28	5.16	w.	12.9	
	1,000	903.5	13.9	-------	30	4.77	w.	11.6	
	1,500	850.4	9.2	-------	35	4.07	w.	12.0	
	2,000	801.0	4.5	-------	40	3.37	wnw.	12.7	
4:21	2,098	791.6	3.6	0.94	41	3.24	wnw.	13.1	
4:22	2,383	764.2	2.4	0.42	37	2.69	wnw.	14.9	
	2,500	752.5	2.5	-------	32	2.34	wnw.	15.1	
4:23	2,564	747.3	2.6	−0.11	29	2.13	wnw.	15.2	
	3,000	708.2	1.3	-------	25	1.68	wnw.	19.4	
4:27	3,321	680.2	0.3	0.30	22	1.37	wnw.	22.4	
	4,000	624.9	−2.2	-------	28	1.43	wnw.	23.1	
4:29	4,089	617.8	−2.5	0.36	29	1.44	wnw.	23.8	
	5,000	550.1	−7.5	-------	32	1.04	wnw.	25.9	
4:33	5,165	538.7	−8.4	0.55	33	0.99	wnw.	25.1	
	6,000	484.3	−14.0	-------	38	0.70	w.	30.5	
4:38	6,434	456.3	−16.9	0.67	41	0.57	w.	29.5	
	7,000	423.8	−21.2	-------	41	0.38	w.	33.2	
4:44	7,869	375.4	−27.9	0.77	41	0.20	w.	32.5	
	8,000	369.1	−28.9	-------	41	0.18	w.	32.3	
	9,000	320.7	−36.2	-------	39	0.08	w.	46.8	
4:49	9,753	286.7	−41.7	0.73	38	0.04	-------	-------	
	10,000	276.6	−43.3	-------	37	0.03	-------	-------	
4:54	11,004	237.7	−49.9	0.66	34	0.01	-------	-------	
4:57	11,766	211.4	−53.8	0.51	32	0.01	-------	-------	Tropopause.
	12,000	203.8	−54.1	-------	32	0.01	-------	-------	
	13,000	174.0	−55.5	-------	32	0.01	-------	-------	
5:06	13,546	160.1	−56.3	0.14	32	0.01	-------	-------	
	14,000	149.0	−58.0	-------	32	(1)	-------	-------	
5:15	15,000	126.9	−61.9	-------	32	(1)	-------	-------	
	15,141	124.2	−62.4	0.38	32	(1)	-------	-------	

SEPTEMBER 18, 1930

A. m.									
6:33	225	995.2	10.8	-------	82	10.62	s.	2.0	Few Cl., W.
6:34	307	985.5	17.2	−7.80	55	10.80	ssw.	3.6	
	500	963.6	16.2	-------	53	9.76	wsw.	5.4	
6:36	896	919.4	14.1	0.53	50	8.04	w.	5.6	
	1,000	908.4	13.4	-------	51	7.84	w.	6.0	
6:37	1,382	867.6	10.8	0.68	53	6.86	wnw.	8.1	
	1,500	856.3	10.0	-------	56	6.88	wnw.	8.2	
	2,000	805.1	6.4	-------	67	6.44	nw.	10.1	
6:40	2,215	784.2	4.9	0.71	72	6.24	nw.	11.2	
	2,500	756.8	5.0	-------	61	5.32	nw.	10.2	
6:42	2,724	736.7	5.1	−0.04	53	4.65	nw.	10.4	
	3,000	711.4	4.1	-------	50	4.10	wnw.	13.1	
6:44	3,593	662.0	2.0	0.36	43	3.03	nw.	11.0	
	4,000	630.2	−0.6	-------	41	2.38	nw.	8.1	
	5,000	554.7	−7.1	-------	37	1.25	nw.	9.5	

[1] Less than 0.01 mb.

TABLE 2.—*Tabulated data of sounding-balloon ascents at Royal Center, Ind., during September, 1930*—Continued

SEPTEMBER 18, 1930—Continued

Time 90th mer.	Altitude, M. S. L.	Pressure	Temperature	$\frac{\Delta t}{100\text{ m.}}$	Humidity: Relative	Humidity: Vapor pressure	Wind: Direction	Wind: Velocity	Remarks
A. m.	*M.*	*Mb.*	°*C.*		*P.ct.*	*Mb.*		*M.p.s.*	
6:50	5,476	521.5	−10.2	0.55	35	0.90	nw.	8.7	
	6,000	486.0	−13.9	-------	34	0.63	nw.	8.5	
	7,000	425.3	−21.1	-------	33	0.31	nw.	9.6	
6:57	7,176	416.2	−22.3	0.59	33	0.28	nw.	9.7	
	8,000	371.0	−31.1	-------	32	0.11	nnw.	10.9	
7:01	8,386	351.6	−35.3	1.07	31	0.07	nw.	9.8	
	9,000	321.1	−39.8	-------	32	0.04	wnw.	10.3	
	10,000	277.5	−47.0	-------	34	0.02	w.	21.4	
7:07	10,447	259.2	−50.3	0.73	35	0.01	w.	23.6	
	11,000	237.8	−52.6	-------	34	0.01	wsw.	33.2	
	12,000	203.4	−56.8	-------	33	0.01	wsw.	33.3	
7:12	12,024	202.9	−56.9	0.42	33	0.01	w.	33.0	Tropopause.
7:15	12,729	181.5	−57.8	0.13	35	(1)	wsw.	26.0	
	13,000	174.6	−58.3	-------	35	(1)	wsw.	28.7	
	14,000	147.9	−60.0	-------	34	(1)	-------	-------	
7:22	14,486	137.2	−60.9	0.18	33	(1)	-------	-------	
	15,000	126.1	−60.5	-------	31	(1)	-------	-------	
7:29	15,783	111.5	−59.8	−0.08	28	(1)	-------	-------	

SEPTEMBER 18, 1930

P. m.									
4:01	225	991.4	25.5	-------	38	12.41	sw.	2.7	Few Cl., few A. Cu.
	500	959.9	22.6	-------	41	11.25	ssw.	5.1	
	1,000	906.0	17.4	-------	47	9.34	ssw.	6.8	
4:04	1,038	902.4	17.0	1.05	47	9.11	sw.	6.8	
	1,500	853.6	13.1	-------	53	7.99	sw.	6.9	
4:06	1,861	818.3	10.0	0.85	58	7.12	wsw.	7.3	
4:07	1,998	804.9	9.7	0.22	60	7.22	w.	8.8	
4:08	2,426	764.3	7.5	0.51	68	7.05	nw.	9.4	
	2,500	758.1	7.7	-------	64	6.73	nw.	9.5	
4:09	2,620	746.5	8.0	−0.26	58	6.22	nnw.	10.1	
4:10	2,803	730.1	6.8	0.66	62	6.13	nnw.	13.1	
	3,000	712.2	6.0	-------	55	5.14	nnw.	13.9	
4:12	3,283	688.5	4.9	0.40	45	3.90	nnw.	12.0	
4:14	3,851	641.9	1.3	0.63	48	3.22	nnw.	7.8	
	4,000	630.4	0.5	-------	45	2.85	nw.	7.4	
4:17	4,739	574.3	−3.2	0.51	30	1.41	w.	5.9	
	5,000	555.4	−4.1	-------	27	1.17	wsw.	5.4	
4:19	5,207	541.2	−4.9	0.36	25	1.02	wsw.	5.2	
	6,000	488.3	−12.2	-------	25	0.54	w.	8.0	
4:27	6,967	429.7	−21.2	0.93	24	0.22	w.	8.7	
	7,000	427.4	−21.5	-------	24	0.22	w.	8.7	
	8,000	372.8	−31.0	-------	24	0.08	wnw.	12.3	
4:33	8,386	352.8	−34.6	0.94	24	0.06	wnw.	12.3	
	9,000	322.6	−41.8	-------	24	0.02	w.	11.4	
4:40	9,649	292.9	−49.5	1.18	24	0.01	wsw.	12.1	
	10,000	277.3	−50.3	-------	24	0.01	wsw.	17.0	
	11,000	248.5	−52.7	-------	23	0.01	sw.	24.7	
4:47	11,509	220.0	−53.9	0.24	22	0.01	wsw.	38.8	
	12,000	204.3	−55.9	-------	22	(1)	sw.	34.0	
4:53	12,534	187.3	−58.1	0.41	22	(1)	wsw.	36.2	Tropopause.
	13,000	174.4	−58.8	-------	22	(1)	wsw.	34.6	
4:59	13,733	154.8	−59.8	0.14	22	(1)	wsw.	29.3	
	14,000	148.3	−60.0	-------	22	(1)	w.	30.7	
5:04	14,946	127.5	−60.5	0.06	22	(1)	wsw.	26.7	
	15,000	126.2	−60.8	-------	22	(1)	wsw.	26.9	
5:05	15,298	120.5	−62.7	0.62	20	(1)	wsw.	21.3	

SEPTEMBER 19, 1930

A. m.									
6:33	225	991.4	16.1	-------	69	12.63	s.	3.1	6 A. Cu., W.
6:33½	345	977.5	15.2	0.75	67	11.58	s.	8.4	
6:34	478	962.3	18.1	−2.18	53	11.01	ssw.	10.8	
	500	958.9	18.1	-------	53	11.01	ssw.	11.2	
6:35	663	941.7	18.5	−0.22	53	11.29	sw.	11.5	
6:35½	865	919.8	19.4	−0.45	48	10.82	sw.	11.8	
	1,000	905.0	18.8	-------	49	10.64	sw.	11.4	
	1,500	853.2	16.5	-------	52	9.77	wsw.	9.3	
	2,000	805.5	14.2	-------	56	9.07	wsw.	7.5	
6:40	2,008	804.3	14.2	0.45	56	9.07	wsw.	7.5	
	2,500	760.0	10.0	-------	58	7.12	w.	8.2	
	3,000	715.0	5.8	-------	60	5.53	wnw.	10.4	
6:45	3,627	660.8	0.5	0.85	62	3.92	wnw.	9.1	
	4,000	631.1	−2.4	-------	65	3.26	w.	11.0	
	5,000	554.5	−10.3	-------	73	1.86	w.	8.2	
6:51	5,189	541.7	−11.8	0.79	75	1.67	-------	-------	
6:52	5,444	524.0	−10.1	−0.67	70	1.82	-------	-------	
	6,000	487.3	−13.5	-------	62	1.19	-------	-------	
6:58	6,916	431.7	−19.2	0.62	48	0.54	-------	-------	
	7,000	427.3	−19.6	-------	48	0.52	-------	-------	
	8,000	372.8	−24.8	-------	45	0.31	-------	-------	
7:06	8,770	335.0	−28.7	0.51	48	0.21	-------	-------	
	9,000	324.9	−30.6	-------	48	0.17	-------	-------	
	10,000	281.7	−39.0	-------	47	0.07	-------	-------	
	11,000	242.7	−47.3	-------	46	0.02	-------	-------	
7:14	11,027	241.5	−47.5	0.83	46	0.02	-------	-------	

[1] Less than 0.01 mb.

TABLE 2.—*Tabulated data of sounding-balloon ascents at Royal Center, Ind., during September, 1930*

SEPTEMBER 19, 1930

Time 90th mer.	Altitude, M. S. L.	Pressure	Temperature	$\frac{\Delta t}{100\text{ m.}}$	Humidity: Relative	Humidity: Vapor pressure	Wind: Direction	Wind: Velocity	Remarks
P. m.	*M.*	*Mb.*	*°C.*		*P. ct.*	*Mb.*		*M.p.s.*	
4:10	225	987.4	27.4	-------	38	13.88	s.	5.4	1 A. Cu., SW.
	500	955.8	24.8	-------	-----	-----	SSW.	11.1	
4:12	726	932.2	22.6	0.96	-----	-----	SSW.	11.4	
4:13	943	909.1	21.5	0.51	-----	-----	SW.	16.4	
	1,000	902.9	21.0	-------	-----	-----	SW.	16.8	
4:14	1,366	865.2	17.5	0.95	-----	-----	SW.	16.4	
4:15	1,467	855.0	17.8	−0.30	-----	-----	SW.	15.0	
	1,500	852.2	17.5	-------	-----	-----	WSW.	14.3	
4:16	1,792	822.9	15.3	0.77	-----	-----	WSW.	16.1	
	2,000	803.5	14.0	-------	-----	-----	WSW.	16.6	
	2,500	756.2	10.8	-------	-----	-----	WSW.	15.4	
4:19	2,818	727.7	8.8	0.63	-----	-----	WSW.	14.6	
4:20	2,920	718.8	9.2	−0.39	-----	-----	WSW.	14.7	
	3,000	712.8	8.5	-------	-----	-----	W.	14.9	
4:21	3,272	688.7	6.1	0.88	-----	-----	W.	15.0	
	4,000	629.7	−0.6	-------	-----	-----	W.	10.2	
4:25	4,278	607.8	−3.1	0.91	-----	-----	W.	10.0	
	5,000	554.5	−8.1	-------	-----	-----	NW.	10.3	
4:30	5,513	518.7	−11.6	0.69	-----	-----	WNW.	8.7	
	6,000	486.9	−14.1	-------	-----	-----	W.	11.5	
4:36	6,728	441.9	−17.9	0.52	-----	-----	W.	16.3	
	7,000	426.4	−20.0	-------	-----	-----	W.	15.3	
	8,000	372.2	−27.6	-------	-----	-----	W.	14.8	
4:42	8,173	362.7	−28.9	0.76	-----	-----	WNW.	13.2	
	9,000	323.0	−35.7	-------	-----	-----	WNW.	9.8	
4:49	9,874	284.1	−42.9	0.82	-----	-----	W.	17.4	
	10,000	279.1	−43.5	-------	-----	-----	W.	17.8	
	11,000	240.2	−48.5	-------	-----	-----	W.	22.2	
4:56	11,433	224.7	−50.6	0.49	-----	-----	WSW.	26.8	
	12,000	205.7	−54.4	-------	-----	-----	W.	25.4	
4:59	12,552	188.7	−58.0	0.66	-----	-----	WSW.	30.0	Tropopause.
	13,000	175.9	−58.1	-------	-----	-----	WSW.	36.0	
	14,000	150.0	−58.2	-------	-----	-----	WSW.	38.3	
5:08	14,444	139.8	−58.3	0.02	-----	-----	W.	27.6	
	15,000	-------	-------	-------	-----	-----	W.	24.7	
5:13	15,519	-------	-------	-------	-----	-----	WSW.	24.0	

SEPTEMBER 20, 1930

A. m.									
6:34	225	991.7	13.0	-------	79	11.83	n.	2.8	7 St. Cu., W.
6:35	394	971.9	13.0	0.00	72	10.79	n.	7.0	
	500	959.6	12.3	-------	72	10.30	n.	8.6	
6:36	884	916.7	9.9	0.63	72	8.78	n.	11.2	
	1,000	903.0	10.9	-------	72	9.39	n.	8.6	
6:36½	1,022	901.7	11.1	−0.87	72	9.51	n.	8.3	
6:37	1,184	884.3	10.4	0.43	82	10.34	nnw.	6.1	
6:38	1,359	865.9	10.9	−0.29	84	10.95	w.	6.8	
	1,500	850.4	11.8	-------	85	11.76	w.	8.5	
6:39	1,663	835.1	12.8	−0.63	86	12.71	wsw.	12.9	
	2,000	802.0	11.2	-------	86	11.44	w.	15.4	
6:42	2,500	755.5	8.7	0.49	86	9.68	w.	18.8	
	3,000	710.1	5.2	-------	86	7.60	-------	-------	
6:45	3,623	658.3	0.8	0.70	86	5.56	-------	-------	
6:46	3,868	638.8	1.8	−0.41	70	4.86	-------	-------	
	4,000	627.5	0.9	-------	71	4.63	-------	-------	
6:48	4,792	568.9	−4.7	0.70	74	3.06	-------	-------	
	5,000	554.4	−6.4	-------	77	2.76	-------	-------	
6:50	5,215	538.9	−8.2	0.83	80	2.46	-------	-------	
6:51	5,747	503.2	−10.6	0.45	60	1.49	-------	-------	
	6,000	486.9	−12.3	-------	60	1.28	-------	-------	
6:53	6,545	453.2	−16.1	0.69	60	0.91	-------	-------	
	7,000	426.5	−18.5	-------	58	0.70	-------	-------	
6:55	7,281	410.8	−20.0	0.53	56	0.58	-------	-------	
6:57	7,696	388.3	−23.8	0.92	54	0.39	-------	-------	
	8,000	372.7	−25.7	-------	52	0.31	-------	-------	
	9,000	324.5	−32.0	-------	47	0.15	-------	-------	
7:05	9,470	303.0	−35.0	0.63	45	0.10	-------	-------	
7:08	9,993	280.9	−40.3	1.01	43	0.05	-------	-------	
7:10	10,377	265.5	−41.5	0.31	43	0.05	-------	-------	
	11,000	241.9	−48.1	-------	43	0.02	-------	-------	
7:14	11,271	232.1	−51.0	1.06	43	0.02	-------	-------	

SEPTEMBER 20, 1930

P. m.									
4:10	225	989.9	20.7	-------	31	7.57	nw.	3.6	2 Cl. St., W.
	500	958.5	18.3	-------	-----	-----	W.	3.8	
4:12	779	927.5	15.8	0.88	-----	-----	WNW.	4.1	Pressure record poor; altitudes determined from 2-theodolite observations; pressures computed from altitudes and temperatures.
	1,000	904.0	13.9	-------	-----	-----	WNW.	4.9	
4:15	1,457	855.3	10.1	0.84	-----	-----	WNW.	6.7	
	1,500	851.4	9.9	-------	-----	-----	WNW.	6.9	
	2,000	800.0	7.5	-------	-----	-----	W.	8.8	
4:17	2,222	779.4	6.4	0.48	-----	-----	W.	11.1	
4:18	2,399	762.7	7.5	−0.62	-----	-----	W.	12.0	
	2,500	753.5	6.8	-------	-----	-----	W.	12.3	
4:20	2,757	730.1	5.0	0.70	-----	-----	W.	13.1	

TABLE 2.—*Tabulated data of sounding-balloon ascents at Royal Center, Ind., during September, 1930*—Continued

SEPTEMBER 20, 1930—Continued

Time 90th mer.	Altitude, M. S. L.	Pressure	Temperature	$\frac{\Delta t}{100\text{ m.}}$	Humidity: Relative	Humidity: Vapor pressure	Wind: Direction	Wind: Velocity	Remarks
P. m.	*M.*	*Mb.*	*°C.*		*P. ct.*	*Mb.*		*M.p.s.*	
4:21	2,950	713.0	5.2	−0.10	-----	-----	W.	14.5	
	3,000	709.1	4.9	-------	-----	-----	W.	14.9	
4:24	3,921	632.2	0.1	0.52	-----	-----	W.	18.6	
	4,000	626.0	−0.4	-------	-----	-----	W.	18.7	
4:28	4,889	559.4	−6.1	0.64	-----	-----	W.	21.0	
	5,000	550.9	−6.0	-------	-----	-----	W.	20.9	
4:29	5,133	542.3	−5.9	−0.08	-----	-----	W.	20.1	
	6,000	485.0	−13.6	-------	-----	-----	W.	23.8	
4:35	6,340	463.5	−16.6	0.89	-----	-----	W.	25.5	
4:36	6,709	-------	-------	-------	-----	-----	W.	24.5	

SEPTEMBER 21, 1930

4:27	225	986.5	23.1	-------	35	9.90	s.	3.6	Cloudless.
4:28	437	962.8	23.1	0.00	34	9.62	SSW.	8.3	
	500	954.8	22.6	-------	34	9.33	SSW.	8.5	
	1,000	900.7	18.3	-------	36	7.57	SSW.	10.8	
4:31	1,443	856.1	14.6	0.85	38	6.32	SW.	12.2	
	1,500	850.0	14.6	-------	39	6.48	SW.	12.4	
4:32	1,678	832.7	14.5	0.41	41	6.77	WSW.	13.3	
4:33	1,945	806.7	13.5	0.37	46	7.12	W.	15.5	
	2,000	800.9	13.7	-------	45	7.06	W.	16.1	
4:34	2,079	794.0	13.9	−0.30	44	6.99	W.	17.0	
	2,500	755.0	10.6	-------	48	6.13	WNW.	19.6	
	3,000	710.9	6.7	-------	53	5.20	WNW.	24.4	
4:38	3,368	679.7	3.9	0.78	57	4.60	WNW.	23.4	
4:39	3,563	663.6	4.1	−0.10	52	4.26	W.	21.9	
	4,000	628.5	0.7	-------	52	3.34	W.	22.4	
4:42	4,668	578.1	−4.5	0.78	52	2.19	W.	27.3	
4:43	4,856	564.4	−4.3	−0.11	50	2.14	W.	28.8	
	5,000	554.0	−5.2	-------	48	1.91	W.	29.3	
4:46	5,671	508.5	−9.2	0.60	41	1.15	W.	28.2	
4:47	5,884	494.7	−8.9	−0.14	38	1.09	WNW.	26.8	
	6,000	486.4	−9.9	-------	38	1.00	WNW.	25.2	
4:49	6,406	462.2	−13.6	0.90	38	0.72	W.	29.4	
	7,000	425.7	−18.6	-------	37	0.44	W.	29.4	
	8,000	372.8	−27.0	-------	34	0.18	W.	32.3	
4:53	8,216	361.8	−28.8	0.84	34	0.15	W.	35.2	
	9,000	325.9	−35.6	-------	33	0.07	W.	39.4	
4:59	9,717	291.8	−41.9	0.87	33	0.03	W.	33.8	
	10,000	282.9	−44.0	-------	33	0.03	W.	34.7	
	11,000	241.0	−51.5	-------	33	0.01	W.	33.6	
5:04	11,057	238.5	−51.9	0.75	33	0.01	-------	-------	

SEPTEMBER 24, 1930

3:58	225	989.0	23.9	-------	77	22.85	s.	4.5	6 A. St., SW 4 St., SW.
3:59	316	978.8	23.5	0.44	-----	-----	SSW.	8.1	
	500	958.9	22.6	-------	-----	-----	SSW.	11.2	
4:00	599	947.6	22.1	0.49	-----	-----	SSW.	12.1	
	1,000	905.4	19.7	-------	-----	-----	SW.	17.3	
4:04	1,458	857.7	16.9	0.61	-----	-----	SW.	20.0	
	1,500	854.0	16.7	-------	-----	-----	SW.	19.9	
	2,000	805.0	13.9	-------	-----	-----	SW.	22.0	
4:07	2,262	780.0	12.4	0.56	-----	-----	SW.	21.8	
	2,500	758.5	11.0	-------	-----	-----	SW.	21.4	
	3,000	715.0	8.1	-------	-----	-----	SW.	20.6	
4:11	3,137	702.2	7.3	0.58	-----	-----	SW.	20.1	
4:14	3,932	637.0	2.6	0.59	-----	-----	-------	-------	
	4,000	632.1	2.4	-------	-----	-----	-------	-------	
	5,000	558.1	−1.0	-------	-----	-----	-------	-------	Intermittent showers all day; Sprinkling rain at time of flight.
4:18	5,165	546.5	−1.6	0.34	-----	-----	-------	-------	
	6,000	492.2	−7.5	-------	-----	-----	-------	-------	
4:24	6,474	462.4	−10.8	0.70	-----	-----	-------	-------	
	7,000	431.3	−14.0	-------	-----	-----	-------	-------	
	8,000	377.1	−20.0	-------	-----	-----	-------	-------	
4:32	8,212	367.3	−21.3	0.60	-----	-----	-------	-------	
	9,000	330.0	−27.1	-------	-----	-----	-------	-------	
4:38	9,548	305.5	−31.1	0.73	-----	-----	-------	-------	
	10,000	287.2	−34.7	-------	-----	-----	-------	-------	
4:45	10,869	252.6	−41.8	0.81	-----	-----	-------	-------	
	11,000	247.9	−43.0	-------	-----	-----	-------	-------	
4:51	11,795	219.8	−50.2	0.91	-----	-----	-------	-------	
	12,000	213.0	−52.1	-------	-----	-----	-------	-------	
4:56	12,650	192.4	−58.2	0.94	-----	-----	-------	-------	
	13,000	181.9	−60.5	-------	-----	-----	-------	-------	
5:03	13,479	168.4	−63.7	0.66	-----	-----	-------	-------	
	14,000	154.8	−67.4	-------	-----	-----	-------	-------	Tropopause.
5:10	14,357	145.7	−69.9	0.71	-----	-----	-------	-------	
	15,000	130.9	−66.7	-------	-----	-----	-------	-------	
5:16	15,020	130.5	−66.6	−0.50	-----	-----	-------	-------	
5:21	15,461	121.4	−64.0	−0.59	-----	-----	-------	-------	

TABLE 2.—*Tabulated data of sounding-baloon ascents at Royal Center, Ind., during September, 1930*—Continued

SEPTEMBER 26, 1930

Time 90th mer.	Altitude, M. S. L.	Pressure	Temperature	Δt 100 m.	Humidity: Relative	Humidity: Vapor pressure	Wind: Direction	Wind: Velocity	Remarks
P. m.	*M.*	*Mb.*	°*C.*		*P. ct.*	*Mb.*		*M.p.s.*	
4:02	225	980.7	11.2	-------	69	9.18	w.	9.4	10 St. Cu., WSW.
4:03	411	959.1	11.0	0.11	73	9.58	wsw.	13.5	
	500	953.6	10.2	-------	76	9.45	wsw.	15.7	
	1,000	892.6	5.8	-------	92	8.48	-------	-------	Base of St. Cu.= 867 M. m.s.l.
4:07	1,242	867.0	3.6	0.89	100	7.90	-------	-------	
	1,500	839.3	2.2	-------	99	7.09	-------	-------	
	2,000	788.0	−0.5	-------	98	5.74	-------	-------	
4:15	2,492	742.1	−3.2	0.54	96	4.50	-------	-------	
	2,500	740.8	−3.0	-------	94	4.48	-------	-------	
4:16	2,577	734.2	−1.5	−2.00	79	4.27	-------	-------	
4:18	2,900	705.1	0.0	−0.46	58	3.54	-------	-------	
	3,000	696.0	−0.5	-------	58	3.40	-------	-------	
4:22	3,638	642.7	−3.5	0.47	56	2.56	-------	-------	
4:23	3,808	629.0	−1.8	−1.00	43	2.27	-------	-------	
	4,000	614.5	−2.0	-------	41	2.12	-------	-------	
4:27	4,461	579.4	−2.6	0.12	37	1.82	-------	-------	
	5,000	542.1	−4.1	-------	28	1.22	-------	-------	
4:35	5,752	491.9	−6.2	0.28	15	0.55	-------	-------	
	6,000	477.1	−7.8	-------	15	0.48	-------	-------	
	7,000	418.7	−14.4	-------	13	0.23	-------	-------	
4:42	7,211	406.9	−15.8	0.66	13	0.20	-------	-------	
	8,000	366.5	−20.9	-------	12	0.11	-------	-------	
4:49	8,519	341.2	−24.3	0.65	12	0.08	-------	-------	
	9,000	319.4	−28.6	-------	13	0.06	-------	-------	
4:56	9,716	288.6	−35.1	0.90	14	0.03	-------	-------	
	10,000	277.4	−36.8	-------	14	0.03	-------	-------	
5:01	10,710	249.9	−41.0	0.59	14	0.02	-------	-------	
5:02	10,948	241.3	−40.2	−0.34	14	0.02	-------	-------	
	11,000	239.9	−40.6	-------	14	0.02	-------	-------	
	12,000	206.6	−48.4	-------	12	0.01	-------	-------	
5:08	12,236	199.1	−50.4	0.79	12	(1)	-------	-------	Tropopause.
	13,000	177.3	−52.0	-------	12	(1)	-------	-------	
5:16	13,397	166.6	−52.9	0.22	12	(1)	-------	-------	

SEPTEMBER 28, 1930

Time 90th mer.	Altitude, M. S. L.	Pressure	Temperature	Δt 100 m.	Humidity: Relative	Humidity: Vapor pressure	Wind: Direction	Wind: Velocity	Remarks
4:00	225	990.5	17.0	-------	33	6.40	w.	5.7	Cloudless.
	500	957.5	14.5	-------	35	5.78	w.	8.2	
	1,000	923.8	10.1	-------	38	4.70	w.	10.4	
4:03	1,241	877.2	7.9	0.90	40	4.26	w.	11.0	
	1,500	850.0	5.7	-------	43	3.94	w.	10.8	
4:05	1,987	800.5	1.7	0.83	48	3.31	wnw.	15.9	
	2,000	799.5	1.8	-------	47	3.27	wnw.	16.2	
4:06	2,169	782.6	3.4	−0.93	30	2.34	wnw.	18.9	
	2,500	751.0	2.3	-------	47	3.39	nw.	29.6	
4:08	2,510	750.4	2.3	0.32	48	3.46	nw.	29.8	Pressure trace questionable; altitudes determined from 2-theodolite observations; pressure computed from altitudes and temperatures.
4:09	2,902	714.6	−0.2	0.64	57	3.43	nw.	30.6	
	3,000	705.0	−0.6	-------	57	3.31	nw.	30.6	
4:11	3,751	642.2	−4.0	0.45	57	2.50	wnw.	28.2	
	4,000	622.1	−5.0	-------	53	2.14	wnw.	28.8	
4:13	4,353	594.9	−6.4	0.40	48	1.72	wnw.	28.7	
	5,000	547.7	−10.5	-------	40	1.00	wnw.	29.8	
4:17	5,790	493.6	−15.5	0.63	30	0.48	wnw.	25.8	
	6,000	480.9	−17.0	-------	30	0.42	wnw.	21.5	
	7,000	420.4	−24.0	-------	29	0.21	wnw.	23.2	
	8,000	365.3	−31.1	-------	28	0.10	wnw.	30.2	

[1] Less than 0.01 mb.

TABLE 2.—*Tabulated data of sounding-baloon ascents at Royal Center, Ind., during September, 1930*—Continued

SEPTEMBER 28, 1930—Continued

Time 90th mer.	Altitude, M. S. L.	Pressure	Temperature	Δt 100 m.	Humidity: Relative	Humidity: Vapor pressure	Wind: Direction	Wind: Velocity	Remarks
P. m.	*M.*	*Mb.*	°*C.*		*P. ct.*	*Mb.*		*M.p.s.*	
4:25	8,613	334.7	−35.4	0.70	28	0.06	wnw.	26.8	
	9,000	316.8	−38.5	-------	27	0.04	wnw.	24.7	
	10,000	273.2	−46.5	-------	26	0.02	wnw.	30.7	
4:31	10,503	253.0	−50.5	0.80	25	0.01	wnw.	29.1	
	11,000	234.1	−53.6	-------	25	0.01	w.	26.7	
4:37	11,996	200.4	−59.7	0.62	25	(1)	w.	40.0	Tropopause.
	13,000	171.0	−60.1	-------	25	(1)	w.	31.4	
4:41	13,423	159.6	−60.3	0.04	25	(1)	w.	26.7	
4:42	13,488	-------	-------	-------	-------	-------	w.	26.0	

SEPTEMBER 29, 1930

4:02	225	992.1	17.0	-------	47	9.11	n.	4.2	Few A. Cu., W.
	500	960.0	14.4	-------	51	8.37	nnw.	6.0	
	1,000	905.2	9.7	-------	60	7.22	nnw.	4.3	
4:06	1,261	876.7	7.2	0.95	64	6.50	nw.	7.3	
4:07	1,476	854.1	7.5	−0.14	64	6.64	nw.	10.9	
	1,500	851.5	7.4	-------	64	6.59	nw.	11.1	
	2,000	800.1	5.5	-------	64	5.78	wnw.	17.0	
4:09	2,148	786.9	4.9	0.39	64	5.54	w.	19.3	
	2,500	755.0	3.2	-------	60	4.61	w.	21.6	
4:11	2,539	750.0	3.0	0.48	60	4.55	w.	21.6	
	3,000	709.7	−0.7	-------	68	3.92	wnw.	23.7	
4:15	3,353	677.5	−3.5	0.80	74	3.39	wnw.	25.1	
4:16	3,769	642.7	−4.9	0.34	50	2.04	wnw.	23.0	
4:17	3,923	630.3	−4.5	−0.26	43	1.81	wnw.	23.0	

SEPTEMBER 30, 1930

4:04	225	997.6	15.3	-------	50	8.70	n.	5.5	Few Ci., NW.
	500	965.0	13.1	-------	53	7.99	n.	6.6	Cu., NW.
	1,000	909.4	9.1	-------	59	6.82	n.	6.4	Pressure trace questionable; altitude determined from 2-theodolite observations; pressure computed from altitudes and temperatures.
	1,500	856.2	5.1	-------	66	5.79	nnw.	5.1	
4:09	1,784	826.4	2.8	0.80	69	5.15	nnw.	4.9	
	2,000	805.0	4.1	-------	54	4.42	nnw.	8.8	
4:11	2,230	782.4	5.5	−0.61	39	3.52	nnw.	11.6	
	2,500	757.0	5.3	-------	33	2.94	nnw.	10.6	
4:11½	2,547	752.6	5.3	0.06	32	2.85	nnw.	10.4	
4:12	2,628	745.2	5.5	−0.25	30	2.71	nnw.	10.5	
4:14	3,002	711.7	5.0	0.13	28	2.44	nnw.	18.4	
	4,000	626.0	−1.3	-------	31	1.70	nw.	18.6	
	5,000	551.1	−7.5	-------	34	1.11	nw.	19.7	
	6,000	486.1	−13.8	-------	37	0.69	nw.	20.2	
4:23	6,337	465.5	−15.9	0.63	38	0.59	nw.	21.4	
	7,000	427.0	−20.5	-------	38	0.38	nw.	20.9	
	8,000	372.5	−27.4	-------	38	0.19	nw.	21.9	
	9,000	323.2	−34.3	-------	38	0.09	nw.	27.6	
4:33	9,531	299.1	−38.0	0.69	38	0.06	nw.	26.7	
	10,000	279.5	−41.4	-------	37	0.04	nw.	25.4	
	11,000	241.6	−48.7	-------	36	0.01	wnw.	28.0	
	12,000	206.6	−56.0	-------	35	0.01	wnw.	32.6	
4:43	12,118	202.4	−56.9	0.73	35	0.01	nw.	32.8	
	13,000	-------	-------	-------	-------	-------	nw.	34.0	
4:48	13,591	-------	-------	-------	-------	-------	nw.	38.0	

[1] Less than 0.01 mb.

RECORD SHORT-PERIOD RAINFALLS IN FLORIDA

GEORGE V. FISH

[Weather Bureau Office, Tampa, Fla.]

The following is a study of record rainfalls for 5, 10, 15, and 30 minutes and for 1, 2, and 24 hours, together with the maximum monthly amounts occurring on or near the coast of Florida, as determined from the data of the first-order Weather Bureau stations in that State.

This subject is important owing to its value to architects, engineers, and all engaged in the aviation industry. They desire to ascertain just what they may expect in the future as inferred from the records of what has happened in the past.

Architects have to consider these values in planning the roofs and foundations of buildings. Engineers consider carefully the amount of run-off they may expect in the season of summer showers. In so far as may be considered justified, they allow a considerable margin for the exceptionally heavy rainfall.

Since an east coast mail pilot was caught in the thunderstorm as reported by James W. Smith (MONTHLY WEATHER REVIEW, vol. 58, March, 1930, pp. 117–118) every commercial pilot in Florida has had an increased respect for these tremendous downpours of rainfall. The tendency of pilots, previous to that time, was to take off with their ship, try to find a "hole" in the thick weather and get the mail through to their destination. Since that time they have made many flights in weather that was far from good, but only after they had received reports assuring them of frequent breaks in the threatening weather confronting them.

The tables show that by far the greater number of these record amounts occurred in connection with thunderstorms. On the west coast of Florida, from Pensacola to Tampa, practically all the record falls occurred in thunderstorms, though the tabulated amounts for Apalachicola indicate that tropical storms may be a factor in that record. The existing short-period records for Apalachicola are comparatively brief. It is believed that

a much longer record would eliminate tropical storms as the controlling factor, except possibly for the 24-hour and monthly amounts.

It is interesting to note that the greatest monthly catch at Apalachicola, 27.73 inches in September, 1924, is only 0.13 inch less than the maximum for the State, reported by first-order stations, that is, 27.86 inches at Miami in October, 1908. It should be noted that this later amount was recorded before a first-order station was established at Miami.

Both of these extremely heavy monthly rainfalls may be traced to the passage of tropical storms. They are likely to stand for some time as records.

It is thought that but few heavy rainfalls are recorded in Florida during the late fall and winter months. The tables, however, indicate that rains approximating an inch in 30 minutes may occur during practically all the months of the year, at all Florida stations, though it is evident that the short-period amounts are decidedly greatest in the summer and early fall months.

The heaviest rainfall for five minutes, 1.05 inches, occurred at Tampa, in September, 1924, during an afternoon thundershower. The same storm caused a downpour of 1.66 inches at Tampa in a 10-minute period. Pensacola has the record for the next three periods, 2.27 inches in 15 minutes; 3.63 inches in 30 minutes, and 4.27 inches in 1 hour, all occurring during a thunderstorm in October, 1909. Key West, with a record rainfall of 7.08 inches in two hours stands well ahead of all the other stations for that period. Miami has recorded the greatest amount in 24 hours, 15.10 in November, 1925. It, too, occurred in connection with a thunderstorm.

Precipitation, record amounts

APALACHICOLA

[R thunderstorm; DG, disturbance in Gulf; GR, general rain; TD, tropical disturbance; H, hail]

	January	February	March	April	May	June	July	August	September	October	November	December
5 minutes	0.36	0.29	0.40	0.53	0.78	0.40	0.42	0.44	0.56	0.65	0.38	0.32
	R	R	R	R	R	R	GR	R	R H	R	R	R
Year	1923	1929	1928	1928	1923	1926	1929	1922	1927	1927	1930	1924
10 minutes	0.54	0.51	0.61	0.86	1.28	0.68	0.78	0.72	0.88	1.15	0.63	0.50
	R DG	R	1925 R	R	R	R	R	R	R H	R	R	R
Year	1926	1929	1928 R	1928	1923	1926	1931	1924	1927	1927	1930	1922
15 minutes	0.74	0.66	0.80	1.07	1.65	0.93	1.02	0.96	0.98	1.38	0.75	0.59
	R DG	R	R	R	R	R	R	R	R	R	R	R
Year	1926	1929	1925	1928	1923	1926	1931	1922	1930	1927	1930	1922
30 minutes	1.06	1.05	1.39	1.72	2.27	1.52	1.45	1.62	1.38	2.10	1.04	0.80
	R DG	R	R	R	R	R	R	R	R	R	R	GR
Year	1926	1929	1928	1928	1923	1929	1924	1922	1930	1927	1930	1922
1 hour	1.20	1.46	2.06	2.64	2.72	2.41	1.62	2.53	1.75	2.73	1.55	1.23
	R DG	R	R	R	R	R	R	R	TD	R	R	GR
Year	1926	1929	1928	1928	1923	1929	1924	1922	1924	1927	1930	1922
2 hours	1.74	2.09	2.66	3.75	2.97	2.82	1.65	3.10	2.47	3.09	2.24	1.50
	R	R	R	R	R	R	R	R	TD	R	R	GR
Year	1930	1929	1929	1928	1923	1929	1923	1922	1924	1927	1930	1922
24 hours	5.15	3.61	5.87	6.32	4.70	5.41	7.14	7.04	10.12	5.65	5.84	6.02
		DG	R	R				R		R	R	
Year	1915	1924	1928	1929	1907	1910	1916	1925	1906	1927	1930	1918
Month	11.89	10.44	13.97	18.62	9.27	14.90	17.29	14.09	27.73	9.12	8.67	15.88
			R	R					TD		R	
Year	1915	1919	1928	1928	1922	1910	1921	1912	1924	1915	1930	1918

Greatest amounts in 24 hours and for the month for period November 1903, to date. All other amounts for period since July, 1922. No information available as to conditions attending rainfall prior to establishment of first-order station in July, 1922.

Precipitation, record amounts—Continued

JACKSONVILLE

	January	February	March	April	May	June	July	August	September	October	November	December
5 minutes	0.43	0.42	0.53	0.62	0.57	0.67	0.67	0.78	0.62	0.50	0.37	0.56
Year	1925	1922	1930	1907	1907	1901	1917	1901	1891	1904	1903	1905
10 minutes	0.53	0.70	0.91	0.91	0.94	1.18	1.19	1.20	1.18	0.72	0.55	0.77
Year	1925	1922	1905	1907	1919	1901	1917	1907	1891	1904	1896	1905
15 minutes	0.82	0.97	1.25	1.09	1.24	1.44	1.65	1.59	1.54	1.06	0.71	0.78
Year	1895	1922	1905	1907	1919	1901	1917	1907	1891	1904	1896	1905
30 minutes	1.01	1.53	1.53	1.21	1.74	2.07	2.47	2.13	3.12	1.26	0.97	0.97
Year	1895	1902	1905	1907	1919	1901	1917	1920	1889	1904	1914	1927
1 hour	1.13	1.61	1.89	1.70	2.34	3.13	2.93	2.65	3.12	1.82	1.19	1.27
Year	1895	1902	1930	1893	1903	1901	1917	1920	1889	1894	1920	1927
2 hours	1.90	1.61	2.23	2.04	3.78	3.21	3.01	2.72	3.14	2.15	1.50	1.60
Year	1915	1902	1930	1900	1903	1901	1917	1920	1907	1894	1920	1927
24 hours	3.09	4.16	4.47	4.81	9.06	7.66	4.89	6.18	9.86	5.15	3.75	4.97
Year	1881	1920	1901	1900	1903	1919	1926	1905	1984	1890	1884	1916
Month	9.12	9.16	10.00	8.19	14.80	13.79	14.97	10.97	21.79	16.25	6.09	7.76

KEY WEST

		R	R	R	R				R		R	R
5 minutes	0.46	0.39	0.60	0.53	0.64	0.65	0.53	0.57	0.49	0.50	0.46	0.39
Year	1924	1925	1911	1904	1925	1899	1912	1926	1918	1912	1911	1912
		R	R	R	R		R		R		R	R
10 minutes	0.81	0.61	0.93	1.02	1.03	0.95	0.73	1.02	0.90	0.95	0.61	0.73
Year	1924	1913	1911	1904	1925	1899	1926	1926	1918	1912	1911	1930
		R	R	R	R	R	R		R		TD	R
15 minutes	0.96	0.77	1.19	1.45	1.30	1.25	1.04	1.52	1.06	1.20	0.78	0.95
Year	1924	1913	1911	1904	1925	1922	1926	1926	1918	1912	1906	1930
		R	R	R	R	R	R			TD	TD	R
30 minutes	1.02	0.96	1.30	1.83	2.24	2.01	1.49	2.68	1.71	1.87	1.09	1.64
Year	1924	1913	1911	1904	1925	1922	1926	1926	1920	1909	1906	1930
		R	R	R	R		R			TD	TD	R
1 hour	1.63	2.29	1.38	1.98	2.78	2.64	2.00	4.30	2.12	3.35	1.71	2.38
Year	1899	1902	1905	1904	1929	1900	1916	1926	1920	1909	1906	1930
		R	R	R	R	R	R			TD	TD	R
2 hours	1.16	1.30	1.72	2.08	3.45	2.27	2.89	7.08	2.24	5.28	2.95	2.61
Year	1915	1913	1905	1919	1929	1912	1916	1926	1920	1909	1906	1930
		R	R				R		TD	TD	TD	
24 hours	3.97	2.99	4.52	3.23	5.83	5.48	7.46	8.32	11.95	11.23	8.86	3.93
Year	1879	1902	1905	1882	1904	1900	1916	1926	1919	1909	1906	1879
Month	7.65	7.19	6.89	4.99	13.01	12.97	10.89	15.83	17.29	19.77	10.82	10.03

Precipitations 24 hours, 60 years; 5 and 10 minutes and 1 hour, 34 years; 15 and 30 minutes and 2 hours, 27 years.

MIAMI

	R	R		R	R	R	R	R	R		R	R
5 minutes	0.29	0.58	0.51	0.55	0.59	0.56	0.64	0.55	0.62	0.49	0.53	0.35
Year	1926	1922	1919	1914	1923	1929	1926	1930	1924	1922	1925	1918
	R	R		R	R	R	R	R	R		R	R
10 minutes	0.50	0.97	0.96	1.02	0.89	0.98	0.82	0.95	0.98	0.79	0.78	0.66
Year	1926	1922	1919	1914	1923	1929	1930	1930	1924	1922	1920	1918
	R	R		R	R	R	R	R	TD		R	R
15 minutes	0.71	1.19	1.34	1.32	1.29	1.31	1.12	1.06	1.32	1.08	1.09	0.88
Year	1926	1922	1919	1914	1913 R 1925 R	1929	1930	1927	1924	1924	1925	1918
	R	R		R	R	R	R	TD	R		R	R
30 minutes	1.13	1.74	2.26	1.83	2.15	1.76	1.82	1.53	1.86	1.83	2.07	1.20
Year	1926	1922	1919	1914	1925	1927	1926	1916	1914	1915	1925	1918
	R	R		R	R		R	TD	TD		R	
1 hour	1.76	2.45	2.82	2.05	2.96	2.74	2.68	2.83	2.77	2.69	3.50	1.93
Year	1926	1922	1919	1914	1925	1930	1926	1916	1928	1929	1925	1929
	R	R		R	R		R	TD	TD	TD	R	
2 hours	3.07	2.51	3.12	2.63	3.48	3.13	3.01	4.73	4.34	4.66	6.11	3.01
Year	1926	1922	1919	1914	1912	1930	1926	1916	1928	1924	1925	1929
	R	R		R	R		R	TD	TD	TD	R	
24 hours	6.69	2.51	9.04	3.22	9.36	7.15	4.90	6.12	10.58	9.53	15.10	5.31
Year	1926	1922	1919	1917	1930	1930	1926	1916	1929	1924	1925	1929
Month	7.93	5.91	9.74	10.75	18.66	25.34	15.22	13.71	20.35	27.86	17.72	12.06

Number of years of record for excessive precipitation, including greatest in 24 hours, 20. Number of years of record for greatest monthly amounts, 29 for Weather Bureau record; 37 for Weather Bureau and Army records.

Precipitation, record amounts—Continued

PENSACOLA

	January	February	March	April	May	June	July	August	September	October	November	December
5 minutes	0.51	0.61	0.59	0.64	0.57	0.46	0.53	0.60	0.57	0.78	0.65	0.62
Year	1929	1912	1912	1912	1915	1916	1924	1915	1920	1909	1914	1916
10 minutes	0.71	0.94	0.97	1.15	1.01	0.79	0.87	1.13	0.99	1.55	1.16	0.92
Year	1918	1912	1912	1912	1915	1916	1908	1915	1920	1909	1914	1916
15 minutes	0.80	0.96	1.19	1.49	1.31	1.10	1.20	1.27	1.37	2.27	1.64	1.04
Year	1918	1912	1912	1912	1915	1916	1906	1915	1920	1909	1914	1916
30 minutes	1.07	1.30	1.55	2.10	1.97	1.72	2.17	1.90	2.25	3.63	2.20	1.17
Year	1903	1926	1912	1919	1915	1916	1907	1916	1906	1909	1914	1909
1 hour	1.64	1.48	3.01	3.10	2.43	2.23	3.33	3.01	3.73	4.27	3.17	1.89
Year	1903	1926	1912	1919	1915	1916	1907	1922	1906*	1909	1903	1905
2 hours	2.58	1.84	3.98	4.38	2.62	2.43	3.96	4.71	6.14	4.82	5.03	2.15
Year	1903	1926	1912	1919	1915	1916	1907	1919	1906*	1909	1903	1911
24 hours	3.52	5.05	8.32	8.91	5.63	10.70	5.01	9.60	8.56	7.30	7.66	4.32
Year	1881	1881	1913	1919	1915	1887	1896	1919	T.D. 1926	1923	1914	1911
1 month	9.97	12.53	13.37	13.90	9.92	14.11	17.90	18.52	18.65	14.66	14.82	11.06

* 2 days after tropical disturbance.

Precipation, record amounts—Continued

TAMPA

	January	February	March	April	May	June	July	August	September	October	November	December
5 minutes	0.47	0.66	0.55	0.52	0.70	1.00	0.54	0.59	1.05	0.57	0.44	0.42
Year	1904	1927	1900	1928	1930	1900	1920	1906	1924	1928	1903	1907
10 minutes	0.65	1.05	1.05	0.79	1.17	1.50	0.87	1.15	1.66	0.90	0.69	0.82
Year	1904	1927	1900	1921	1930	1900	1920	1898	1924	1928	1911	1907
15 minutes	0.73	1.26	1.40	0.98	1.58	1.90	1.12	1.60	2.03	0.98	0.82	0.94
Year	1909	1927	1900	1921	1930	1900	1910	1898	1924	1928	1911	1907
30 minutes	0.93	1.96	1.50	1.73	2.00	2.45	1.86	2.72	2.44	1.26	1.31	1.33
Year	1912	1927	1900	1920	1930	1900	1920	1925	1924	1902	1926	1907
1 hour	1.28	2.17	1.65	2.56	2.74	3.65	2.61	4.01	2.76	1.52	1.55	1.98
Year	1904	1927	1900	1920	1902	1930	1920	1925	1924	1923	1925	1907
2 hours	1.60	2.40	2.49	2.76	3.04	4.46	2.84	4.59	3.22	2.21	2.04	2.76
Year	1904	1927	1930	1920	1902	1930	1920	1925	1907	1923	1925	1907
24 hours	3.58	4.06	5.62	[1]2.94	3.55	5.54	5.53	5.04	6.56	6.48	4.18	3.93
Year	1914	1902	1930	1930	1923	1909	1925	1915	1897	1921	1916	1907
Month	6.73	6.27	9.87	8.04	9.41	13.47	15.53	17.83	18.93	10.33	4.85	7.36

[1] Amount exceeded this year, 1931, −4.25.

EDWARD H. SMITH ON THE SCIENTIFIC RESULTS OF THE MARION EXPEDITION OF 1928, TO DAVIS STRAIT AND BAFFIN LAND

By W. F. McDONALD

[Weather Bureau, Washington, December, 1931]

Since its establishment in 1913 as a result of the *Titanic* disaster, the international ice patrol has been collecting scientific data on the oceanography of the ice regions of the North Atlantic as an adjunct to its primary work of scouting for bergs and warning shipping of dangerous ice movements.

Lieut. Edward H. Smith has for more than 10 years been concerned with the scientific aspects of the ice-patrol work. In his latest monograph on scientific results of the intensive oceanographical survey conducted by the Coast Guard cutter *Marion* during the 1928 patrol season, he sums up not only the fruits of his own extensive observations and researches but also includes a comprehensive survey of world literature on the subject of polar ice and ice movements.

The work, published as Part 3 of Coast Guard Bulletin No. 19, includes original contributions by Lieutenant Smith toward the solution of such complex questions as the following: In what manner does ice from the Polar Basin, Baffin Bay, and Hudson Bay, contribute to supply the North Atlantic? What is the annual variation in ice limits and number of icebergs? In what proportions do wind and current enter to control the drift of icebergs? Is the effect of ice melting in northern waters a factor of importance in the main system of oceanic circulations? What meteorological and other factors govern the probable seasonal prevalence of ice along the trans-Atlantic steamer routes?

The chief source of the icebergs that drift to the steamer lanes is conclusively demonstrated to be the great Greenland glaciers of the Baffin Bay region. Major productivity of bergs is confined to the 300-mile stretch of west Greenland coast, central on the seventieth parallel of latitude, and comprising Northeast and Disko Bays, but a lag of some months and in some cases years intervenes between the calving of bergs and their final disappearance in the waters off Newfoundland. The character of the weather during the life of a berg has much to do with determining the route over which it drifts, and also its rate of melting.

Lieutenant Smith demonstrates that the quantity and disposition of the great sheets of relatively thin ice, classed as "pack ice" is a most important factor in the number of bergs which reach the vicinity of the steamer lanes. Sheet ice forms annually to an estimated average thickness of six feet over an area believed to be between 400,000 and 500,000 square miles contributory to the northwestern Atlantic. The amount of pack ice formed depends directly upon the severity of the winter temperatures, and perhaps less directly upon other meteorological conditions (such as storminess) which affect the set of the circulations and the mixing of water masses.

Being sheetlike in structure, pack ice responds readily in its movement to wind; in this respect it is perhaps the most responsive of all oceanographic phenomena to meteorological conditions.

Icebergs are not so responsive to wind, because the exposed portion is only a small fraction of the total mass. However, the shape of the berg appears to be quite important in this connection since its manner of drift seems to depend on the ratio of extreme height above water to the maximum depth of immersion rather than upon the relative masses above and below the water line.

The average ratio of height above water to draft in the case of the usual type of Greenland bergs is reported to be much less than commonly supposed. The ratio of 1 to 3 is common in the earlier stages and as low as 1 to 1 has been measured in certain horned or winged disintegration forms.

It is apparent from these and other analogous facts that in general the drift of icebergs is more subject to the influence of sea currents at some depth than to the pressure of wind. Smith adduces quantitative data in respect to the relative importance of wind and current

and his conclusion is best stated in his own language, as follows: "The deeper draft bergs common to Baffin Bay are moved only 4 miles a day by wind, force 6 to 7. In the case of the deeper bergs drifting within the bounds of an ocean current such as the Labrador current, small influences due to frequently shifting winds are masked by simultaneous movements imparted by the much steadier and more enduring slope current."

The variation in drift, to the right of the wind direction, under the Ekman effect, is stressed, and it is stated that "During a period of even moderate to fresh winds the shoaler berg will drift about 14° to the right of the heavier ones in 24 hours and leave the latter some 4 miles astern, the bergs alternately separating and congregating with the play of the winds." This shows conclusively the major influence of the stable ocean currents rather than the winds, in producing the steady travel of bergs over long periods of time.

Strong evidence supports the conclusion that the amount of pack ice moving down the Labrador coast to the Newfoundland banks is a major factor in the arrival of icebergs in the same vicinity. It seems that the ice pack covering the shallower coastal waters fends off the icebergs and keeps them moving southward; contrariwise, with coastal waters free from pack there is stranding and melting of bergs before they attain the region of the Grand Banks. The year 1928 was marked by a great scarcity of pack ice and also of bergs off Newfoundland, while a close estimate in that year indicated that over 700 icebergs were stranded between Belle Isle and Hudson Strait.

Significant correlation is found between the winter atmospheric pressure gradient (December to March), Ivigtut to Belle Isle, and the spring crop of icebergs south of Newfoundland. Forty-seven years of records enter into the computation. Other significant meteorological factors were found, including mainly the pressure anomaly over Iceland, December to March, and the pressure gradient, October to January, between Iceland and Bergen. The combination of these factors indicates that an excess of pressure in winter over Iceland and southern Greenland, especially in December and January, is unfavorable to the movement of icebergs southward toward the Grand Banks and the steamer lanes in the next spring; the opposite relation is unmistakable in its correlation with a greater number of bergs than normal, but shows a smaller correlation coefficient than that between excessive pressure anomalies and poor iceberg years. This indicates the influence of other more obscure factors, such as variations in air and water temperatures in the far north; variations in precipitation, and perhaps sporadic phenomena such as loosening of ice jams in the Arctic Archipelago or Smith Sound, in releasing unusual quantities of bergs.

The *Marion* oceanographic program included a number of surveys to secure basic data for estimation of the dynamic gradients underlying current drifts and variations. The results are of considerable interest to the meteorologist, in revealing the presence of a dynamic cyclone in the sea where the Labrador current meets the Gulf Stream near the "Tail of the Grand Banks," about 49° W. longitude, and 42° N. latitude.

As might be expected this cyclonic circulation in the ocean currents is of much smaller extent though more persistent than the usual atmospheric cyclone. In discussing this peculiar local movement, which, it is worth emphasizing, occurs in the region where the temperature gradient is at a maximum between the cold outflow from the Labrador current, and the warm flow of the Gulf Stream, Smith says:

> This "low," covering an area of over 2,000 square miles, was first discovered by chance in 1921 by following an iceberg as it made the circuit. In 1926 the "low," apparently similar in character to an atmospheric cyclonic depression, was accurately charted by several successive dynamic surveys, prevailing throughout the season. It was present also in April, 1927, but disappeared early that May * * *. In general, the agreement between the berg tracks that have actually been followed and the gradient currents for the same periods, respectively, is so close as to indicate that dynamic projections of this sort may be used as a basis for predicting the tracks that individual bergs are most likely to follow. * * *
>
> The current maps obtained by dynamic surveys have been found to remain reliable for a period of 7 to 15 days around the Grand Banks. Minor fluctuations of short duration have often been observed, however, especially along the boundary of mixed waters and the Gulf Stream. Such swirls or vortices appear to be secondary superficial tongues 5 to 10 miles in width and several times that in length and the tracks of icebergs, especially the small shallow-draft ones, are often modified by such departures.
>
> Occasionally icebergs survive relatively long periods, even when floating in Atlantic Ocean water of high temperature, and they may then make phenomenal journeys. * * * These drifts, however, do not indicate a direct extension of the Labrador current into low latitudes but simply that the bergs in question have been caught up in oceanic vortices that are continually forming over the Atlantic Basin, in which the ice is borne southward instead of following the normal drift. * * * As a matter of fact, it is unusual for a berg to drift south of the fortieth parallel of latitude in the western North Atlantic, the record for the past 20 years showing only 1 such occurrence every 1 to 3 years.

In a footnote, the author adds: "It has already been pointed out that the outlet for icebergs departing on extra southerly drifts is noticeably confined between meridians 46 to 50, almost directly south of the Grand Banks."

The observations of icebergs and ice-pack movement past Newfoundland and along the Grand Banks rather conclusively disprove the existence of a branch of the Labrador current setting steadily westward or southwestward from Cape Race. The Gulf of St. Lawrence does, however, discharge pack ice and icy waters past Nova Scotia, and the supply of cold water from this source, plus the natural cooling processes, seem ample to account for the maintenance of a cold zone between the Gulf Stream and the New England coast.

The study concludes with a most interesting and valuable discussion of the effect of northern ice on the temperature and circulation of the waters of the North Atlantic. Beginning with the estimate that more than 1,000 cubic miles of ice are annually transformed from solid to liquid in the northern North Atlantic along a front from Spitzbergen to Labrador, there is an examination of the propositions, which some students have advanced, that the heat required to melt this enormous quantity of ice produces the chilling effect "which initiates great downpourings of cold bottom waters" and thus serves as the "main energizing agent responsible for the Atlantic circulation." Lieutenant Smith examines these propositions with quantitative estimates of the factors involved.

Of the sea ice present in the Davis Strait-Baffin Bay region (which embodies the major iceberg production in the northern hemisphere) the glacial ice comprising the bergs is only 2 per cent. The remainder represents ice frozen from sea water, in which case the release of latent heat "produces a material retardation in the freezing

process, and this phenomenon, moreover, is of such magnitude in the polar regions that it tends to stabilize the seasonal fluctuations."

It is clear from the small ratio of icebergs to total ice, that the discharge of glacial ice is of no practical moment in the cooling of sea water. Further, the fact that in vertical dimension, total sea ice is only about one-thousandth of the mean depth of the Atlantic shows how superficial the ice processes must be. Melting produces relatively light thaw water, which stratifies stably at the surface and creates a situation in which solar warming of the summer season is largely accumulated as a heat reserve in the upper layer of only 20 to 40 meters depth, underlaid by a tremendous mass of cold water representing the net accumulations from winter cooling by radiation, within the great area of the Polar Basin and its adjacent waters.

The radiation absorbed in the areas of open water, which is thus largely confined to the shallow top layer, is readily lost, with the onset of winter, and is not adequately compensated by the latent heat released by freezing of new ice. These and other considerations lead to a quantitative estimate that only about 10 per cent of the total cooling received by the North Atlantic in the southward discharge of cold currents can be attributed to the cooling effect of ice melting. The final summations are best stated in the author's own words, as follows:

> Obviously, the low temperature character of the Labrador and east Greenland currents is not due to the melting ice with which these streams are charged in spring and summer. These ocean currents are cold because of the small amount of absorption of solar radiation at the earth's surface in the polar regions. * * *
>
> It is interesting to note in the quantitative treatment of these northern seas phenomena that the cooling factors, viz, chilling by the winter atmosphere, ice melting, snowfall, and evaporation, when totaled, outweigh the solar warming of summer. * * * The great major effect therefore tending to maintain more or less of a constant counterbalance over a long period is the warm currents from the Tropics. * * *
>
> Perhaps it is because the ice catches the eye and the imagination more than do the coastal water masses with which it is ordinarily associated that its relative importance in the picture of oceanographic circulation has been overemphasized. The regional difference of density between coastal and oceanic waters is the main spring for the convectional currents. The winds also, by their direct frictional effect, combined with the presence of the coast lines or other hindrances, develop significant slope currents. The transition zones, i. e., the continental edges, and the (submarine) ridges, mark the belts of greatest energy, and in the sea energy is synonomous with current.
>
> Ice melting over the North American and east Greenland shelves helps to accentuate the contrasts between coastal and oceanic waters, thereby intensifying the currents, but emphatically it is not the main cause of propulsion nor is it even a necessary attribute thereof.

The bulletin is amply illustrated with diagrams, charts, and pictures but the lack of a good map of the north polar regions, fully identifying the geographic features to which frequent and repeated reference is made, is the one point of inadequacy found in this interesting and valuable contribution to oceanography.

CLOUD FLIGHTS [1]

By A. LOHR

[Hamburg, Germany]

[Translated by Eric R. Miller and abstracted by L. T. Samuels]

The daily airplane observation flights made by the Deutsche Seewarte at the Fuhlsbüttel airport have been classified and those made at times when the airplane passed through a solid cloud layer, i. e., when during both the ascent and the descent the earth was entirely cut off from view, have been segregated. The percentages of such flights of the total during 1928 and 1929 were 46 and 44, respectively.

The following features are mentioned:

If the lower boundary of a solid cloud sheet consists of Fr. St. or Fr. Nb., then there is no great danger in emerging from the cloud in descent as the turbulence existing near the ground, indicated by the Fr. St. and Fr. Nb., results in the partial dissipation of the lower boundary of low cloud forms. The Fr. St. or Fr. Nb. very frequently extends to within 100 meters of the ground and has a vertical thickness of 100 to 300 meters. With Nb. there follows immediately the transition to the continuous main cloud sheet, whereas with St. there is often observed a separate thick, clear, intermediate stratum between the Fr. St. and the dense continuous St. A far more dangerous condition to aviation occurs when the Fr. St. or Fr. Nb., stratum is absent and the base of the main cloud sheet is only 100 to 150 meters above ground. In such cases the cloud layer may often reach the ground in some places.

The form of the upper surface of the cloud sheet is varied. On many days it appears like an entirely plane surface. At such times a strong temperature inversion always exists at its level. When a heavy accumulation of haze prevails over the upper cloud surface, then from a greater height the cloud layer appears as an absolutely smooth surface. Occasionally the upper surface is slightly rippled and shows an irregular structure, while at other times it is regularly waved. The wave crests may extend lengthwise for a kilometer but are never very high. All of the types of clouds thus far referred to are an indication of little or no vertical motion within the layer.

Turbulence rolls such as occur in a St. Cu. layer are fundamentally different from the above-mentioned wave structure. In summer, it frequently happens that a horizontal upper surface is overtopped by single Cu. heads which indicate local and narrowly limited overheating. Such Cu. forms are frequently surrounded by cloud-free holes in which descending air creates rather strong "falling" bumpiness.

The cumuli of convection exhibit a more stupendous form than the cumuli of turbulence. The former rise most steeply into the heavens and when illuminated by the sun conjure up marvelous pictures by their rugged lights and shadows. From them, occasionally, thunderheads rise upward to 6,000 meters altitude. The strong bumpiness around the edge of such thunderheads is well known. Flying through them can not be sufficiently warned against. Within such clouds vertical gusts reaching from 10 to 15 meters per second are encountered, while below an ordinary cumulus these velocities usually reach only 2 to 4 meters per second, the latter being very successfully employed in early gliding experiments.

In connection with the vertical currents in upwelling Cu. heads there occur the "caps" over the Cu., the latter being composed mostly of ice particles. Often the raised St. layers that are penetrated by the thunderhead spread

[1] Meteorologische Zeitschrift, September, 1930.

out at the flank of the towering head and may rise upward over the latter. At times the veil-like St. may be elevated throughout an extensive region by the underlying turbulent stratum so that it has the appearance from a greater height of a smooth stratus sheet in which the Cu. are embedded as soft fountain-like forms.

In airplane observations it is often necessary to penetrate a uniformly dense, formless cloud mass more than 4,000 meters thick, when frequently it is impossible to see the tips of the wings of the airplane. An extreme case of this kind occurred on January 2, 1930, when upon descending, the airplane entered the cloud at 5,000 meters elevation and emerged from it at about 50 meters above the ground. Such enormous cloud formations appear nearly always to be associated with the passage of a "wind convergence."

During one flight to 7,000 meters elevation, an opportunity was afforded to observe Ci. at close range. The impression obtained was that massive fall-stripes (Fallstreifen) are formed from Ci. clouds and that they (Ci.) are composed of ice crystals.

During a night flight in the autumn of 1928 the gleam of light from the city appeared on the cloud surface with great clearness.

It was occasionally found that the starting of the airplane motor caused the "ripping open of a lane" in a ground fog.

In Cu. of turbulence it was found that the rows ran mostly in long streaks some hundreds of meters apart, parallel to one another, nearly in the direction of the wind. These rows often exhibited cross-rippling.

Although flights within or under the "squall roll" are to be avoided, some flights were started shortly before an oncoming squall. It was found that over a breadth of 3 to 5 kilometers in front of the "squall roll" there exists a strong vertical bumpiness, which disappears, however, directly above the "squall roll." The area behind the "squall head" is, likewise, free from bumpiness.

It was found to be very difficult to estimate correctly the height of clouds from the ground and to judge their vertical extent from their appearance. In a uniform stratus layer, the visibility horizontally and vertically downward sometimes vanishes immediately on entering the cloud, while at other times the ground is visible for a long time through the cloud mass. This may be due to the size and number of the cloud droplets. From a study of fog, being made at the Deutsche Seewarte, it has been found that fog droplets may be regarded as smooth, opaque little disks and, therefore the visibility varies according to the number and radius of the droplets, with the same vapor content of the air.[2]

[2] A drop of any given radius is equivalent in mass to 8 drops of half that radius, while its equatorial cross section is half the sum of the similar cross sections of the 8 small drops. Hence the interference of the 1 large drop, to a beam of light is just half that of the equivalent 8, except in so far as 2 or more of the latter may chance to be along the same line of sight. Clearly then, for any given mass of water in droplet form (fog or cloud) between observer and object, the visibility increases roughly as the radius of the droplets.—ED.

SHOWER AND DRIZZLE

By W. J. HUMPHREYS

Of course everyone knows what a shower is and what a drizzle is too, until he tries to define them. For our present purpose, which is to consider how each is produced, and what therefore under given circumstances it probably signifies, we shall define a shower as a rain of brief duration of medium-sized to large drops; and a drizzle as a very light rain, usually more or less persistent, of quite small drops. If the drops are as much as one twenty-fifth of an inch in diameter, or larger, surely they do not constitute a drizzle, but rain, and fall with a velocity of, roughly, 10 to 25 feet per second, as determined by the size of the drop and density of the air through which they are falling. They can not fall faster than around 25 feet per second because if, and as soon as, through coalescence or otherwise, they become large enough to fall with a greater speed they at once are torn to pieces by the drag of the air through which they are passing. But the rate of fall, whatever it be, is of course, with reference to the air and therefore not at all necessarily the speed of approach toward the surface of the earth. The two velocities, that is, the rate of fall through the air and the rate of approach toward the surface of the earth, are the same only when there is no vertical movement of the air through which the drops are falling. Wherever, then, the upbrush of the air is equal to, or greater than, the rate of fall of the drops through such atmosphere, that particular precipitation can not approach closer to, much less reach, the surface. Of course the greater the height and, consequently, the rarer the air, the greater its upward velocity must be, and in proportion to the decrease of density, to sustain drops of a given size.

Only the largest possible raindrop, one fifth of an inch in diameter, falls through still air of average sea level density at the uniform rate of 25 feet per second. The drops of a moderate rain, as that term is commonly used, having a diameter of, roughly, one twenty-fifth of an inch, have a velocity of fall of about 12 feet per second. Drizzle drops, so small that it would take about 125 of them to span an inch, fall only some two and a quarter feet per second, while cloud droplets, 1,200 of which would stretch barely one inch, fall only one twenty-fifth of a foot, or thereabouts, per second, or 144 feet in the course of an hour.

From the foregoing it is clear that for each given velocity of ascent of the air there is a corresponding minimum size of raindrop that can get through it to lower levels. Smaller drops can not fall while the appreciably larger ones must and do. Hence ascending air carries cloud droplets up and keeps them up until by further condensation, coalescence, or both together, they have grown large enough to overcome the lift of the rising air, whereupon, but *not* until they have so grown, they fall to the earth.

If appreciably rising air carries cloud droplets up, as it certainly does, one asks then how it is that the cloud itself, base and all, is not lifted to greater heights. The explanation is that while the individual droplets are lifted to greater levels fresh cloud is continuously formed in the uprising air as soon as, through expansion, incident to increase of height, it has cooled to its dew point, or saturation temperature. The individual particles are carried up, but continuously replaced by freshly-formed droplets at the same cloudbase level. And if the ascent is gentle the droplets soon are evaporated a little way above in the drier air and no rain is formed.

A drizzle, then, or very gentle rain of quite small drops, occurs only where there is little or no ascent of the air—two and a half feet per second at most. A shower, on the other hand, which consists of relatively large drops, requires for its production vertical convection of consider-

able strength. Furthermore, the shower covers, at any instant, only a rather limited region because the air obviously can not be going up everywhere at the same time over a wide area. Hence also it is of short duration. A persistent rain of largish drops can happen only where the cause of the convection, such as a mountain across the path of the wind, is enduring and fixed in position. But such a rain is not a shower.

So much for the difference between the ways in which drizzles and showers are formed. It will be interesting now to inquire what circumstances lead to vertical convections of the air such as give showers, and what to drizzle rains in which clearly there is but little or no convection. Whether or not marked convection will develop depends on the vertical distribution of temperature, mainly, and to some extent also on that of water vapor, for increase of humidity decreases the density of the air just as does increase of temperature. Convection not only can, but must, ensue wherever and whenever the surface of the earth is considerably warmed (by sunshine chiefly) since it in turn then correspondingly heats the lower air which thereupon expands and becomes lighter. This is the origin of the heat thunderstorm so common in the Tropics and adjacent regions. Where condensation occurs in such cases latent heat of vaporization is rendered sensible and the convection thereby still further accentuated, as is evident from the great height to which the cumulus cloud often towers.

Another way by which the vertical contrast of temperature essential to convection is established is by the importation of colder air above. Still another is the wedging in of cold air under warm air. Both of these ways, overrunning and underrunning, occur along the cold front, or windshift line, and often in such vigorous manner as to produce severe squalls. Still another way of inducing vertical convection, commonly moderate and therefore productive usually of rather gentle showers, is by the gradual heating of the under layer or portion of cool air as it drifts over a surface that becomes increasingly warm with the distance traveled. This applies perfectly to a broad deep mass of air of polar origin drifting equatorward over an ocean. Here, and often on land as well, the showers are indicative of the origin (polar) of the air in which they are occurring.

On the other hand, the lower portion of a current of air of tropical origin moving over the ocean, say, or land either, to higher latitudes, tends to become progressively colder and colder, and thereby so stable that local convection in it is quite impossible. After a time the dew point may be passed with the formation of fog and low cloud out of which a drizzle, light to heavy, may fall, but never a shower, there being no vertical convection, except that small amount incident to the turbulence caused by surface friction.

We therefore are assured that such rains as occur within polar air as it advances equatorward are quite likely to be of the shower type and, conversely, that showers often are convincing evidence that the passing air is of polar origin. Similarly, tropical air moving poleward may afford a drizzle long before a mountain, or a barrier of cold air, is encountered. Also a drizzle is evidence of tropical air on its way to higher latitudes.

Showers evidence the presence of marked vertical convection; drizzle proves the absence of such convection. Showers often indicate the equatorward passing of polar air; drizzle the presence of poleward-moving tropical air. Thus shower and drizzle are well nigh rain extremes—in size of drops, rate of precipitation, nature of origin, and their meteorological significance.

METEOROLOGY AND THE FOREST FIRE PROBLEM

By S. B. SHOW

[United States Forest Service, Washington, D. C.]

Foresters have always recognized the importance of the relationship between weather and forest fires in the West. For a number of years after organized fire suppression was instituted, the relative importance of the various weather factors upon fire suppression during the fire season was unknown, or at best, guessed at. Even in these early days it was generally recognized that occasionally in every fire season there occurred short periods of one or several days when the forest cover was unusually inflammable and at times seemed almost explosive. These periods frequently produced greater damage, burned over area, and suppression costs than the remaining 95 per cent of the fire season. This being so, it was essential that attempts be made to determine the factors that brought about these dangerous periods. It was recognized, of course, that abnormal weather conditions were responsible for these periods, but which of the meteorological conditions were most responsible was unknown to foresters. Obviously, the study of the influencing factors was the first needed step to be undertaken in the solution of this problem.

Accordingly, from 1915 to 1925 this phase of the problem was the subject of several independent studies by various members of the Forest Service in the important fire regions, aiming to supplement the work of the Weather Bureau. The main objective was the determination of the principal climatic causes of the sudden changes in the inflammability of forest fuels.

It was found that during the fire season, for some of the most inflammable of our forest types, wind velocity and direction and relative humidity are the most important meteorological factors affecting the spread of a fire. With wind remaining the same, relative humidity is an exceedingly important factor in controlling the size of fires; the lower the humidity, the greater the size. Similarly, with relative humidity constant, there is an increase in size of fires as the wind velocity increases. The critical periods of explosive inflammability always occur when very low relative humidity occurs together with a high wind velocity. Neither low relative humidity nor high wind velocity alone has resulted in such a high rate of spread as the combination of these two factors. The effect of changes in wind direction on fire control endeavor is obvious.

The prediction of these periods and of their duration is of utmost importance to those engaged in forest fire control. The Weather Bureau began its fire-weather warning service in 1916 in California, and has, year by year, consistently enlarged and improved this service. In 1926 a special fire weather official was assigned to the California district which coincides with Region 5 of the Forest Service. Since that time substantial progress has been made in laying the ground work for systematic fire weather forecasting and increasingly valuable information has been furnished the field officers of the protection agencies. Many special observation points are

now supplied with instruments, owned and installed by the Weather Bureau. Most of these special stations are either ranger headquarters or forest lookout stations, and the forest personnel act as observers.

The fire-weather forecasting service furnished in California can be divided broadly into two classes, one of these services being the telegraphic general fire warning forecasts which are sent out in advance of dangerous fire weather or anticipated lightning storms. These messages emanate from the San Francisco office of the Weather Bureau and are sent to designated fire-fighting agencies in those parts of the State affected. For convenience in this work the Weather Bureau has divided the State into 11 forecasting areas, designated by locality, such as North Coast, Siskiyou, Plateau, North Sierra, etc. The field personnel of the Forest Service have learned from experience to depend upon the reliability of these warnings. When one of these messages is received the tendency is for each man to be more alert; the lookout scans the country more closely, the fireman is on the qui vive, the fire dispatcher makes doubly certain of his sources of man power and equipment, the Ranger stays in closer touch with his protective organization. If a fire warning message comes over a week-end or holiday, often emergency men are hired as an additional preventive measure. If these messages come during the time a fire is burning, very often plans are changed accordingly, especially if the fire is not yet under control. These fire warnings are a very important aid in our fire control.

While such general, more or less broadcast warnings were of value, the need was apparent for more localized forecasts. Such a need is particularly great where there are large going fires. Accordingly, in 1929, through a cooperative agreement between the State, Weather Bureau, and the Forest Service, a portable forecasting unit was set up. This unit consisted of a truck, completely equipped with meteorological instruments and a radio receiving set. The fire weather official was in charge of the unit and had, as an assistant, a radio operator. This unit operated in 1929 and 1930, and is on the job again this season. It is scheduled to visit every national forest throughout the State each season, as well as spending a proportionate amount of time in each State fire district. Contacts are made with Forest Service and State personnel and weather stations maintained by these agencies are checked and inspected. Daily forecasts are made from weather information received over the radio and through observation made by the fire weather officials. These forecasts are made for the locality in which the truck is stationed at the time. A central dispatching agency at the regional Forest Service office is kept informed of the location of the unit at all times, and it is dispatched whenever practicable to going fires anywhere in California.

So far, there have not been as many opportunities as was originally expected to make use of the unit on going fires. On those accasions, however, when forecasts have been given on going fires, the reports from the field as to its value have been most encouraging. For example, on one very large fire, in very inaccessible country, due to forecasts of favorable weather conditions for the following day, an order for a large number of men and additional supplies and equipment was canceled, and the Government saved a very considerable sum of money. Certainly, the value of localized fire warning service has been demonstrated through the performance of this portable forecasting unit. An extension of this localized service, together with a continuance of the constantly improving general fire weather warning forecasts, offers a major opportunity for improving systematic fire protection in California.

THE PROBABLE VALUES OF SEASONAL RAINFALL IN LOS ANGELES FROM 1850 TO 1877

By CHARLES C. CONROY

[Author's Abstract]

Some years ago the writer began to collect material bearing upon the rainfall of the Los Angeles area prior to the establishment of the United States Signal Service office in that city on July 1, 1877. This material was found in private journals and diaries, in printed accounts, and, after 1854, in the files of Los Angeles newspapers. These last yielded an abundance of information, and the author was finally enabled to discover practically every day on which rain had fallen over the entire period.

These daily statements were translated into numerical values by comparison with estimates based upon Weather Bureau measurements of rainfall for similarly described days after July 1, 1877. For example, it was found that days on which rain was said to have fallen steadily but not heavily throughout the day, when checked by the measurements, had an average precipitation of 1.32 inches. Using this method for other descriptions, it was possible to build up a table of daily estimates for the entire period 1850–1877. Monthly and seasonal results followed as a matter of course.

The conclusions were then checked by reference to the recorded measurements of rainfall at San Francisco and San Diego for the same period, a ratio having been worked out for two 10-year periods—one dry and one wet—from the records of all three stations subsequent to July 1, 1877. The use of this method of checking required great care, since there was sometimes an inversion of monthly or even seasonal values, San Diego receiving more rain than San Francisco. Fortunately the local accounts prior to 1877 were in almost all cases so definite that estimates could be made with considerable assurance of their approximate accuracy.

Further checking was done for the period 1871–1877 through comparisons of daily barometric readings at San Francisco and San Diego. For this same period a series of measurements made at Los Angeles by proper exposure of a gage was also found, as were also similar measurements for a single year in the fifties.

No rigid mathematical investigation was possible by these means, but it is believed that the evaluated amounts have a margin of error under 15 per cent.

Since the results cover 27 years, the subsequent records of the Los Angeles Weather Bureau office from 1877 to date may be divided exactly into two equal periods,

The mean seasonal rainfall for the three is found to be as follows:

	Inches
1850–1877	14.09
1877–1904	15.39
1904–1931	14.53

The driest winter in the entire series was that of 1862–63, with an estimated rainfall of 4.30 inches; the wettest, that of 1883–84, with a measured rainfall of 38.18 inches.

In the first of these 27-year periods there was a relatively wet series of seasons from 1851 to 1862; two disastrously dry seasons followed; then came another relatively wet series ending on June 30, 1869, and finally a dry series ending on June 30, 1877.

The individual seasonal estimates are as follows:

	Inches		Inches
1850–51	8.60	1864–65	13.60
1851–52	15.30	1865–66	15.40
1852–53	17.20	1866–67	19.80
1853–54	15.50	1867–68	23.50
1854–55	18.00	1868–69	15.30
1855–56	12.60	1869–70	7.20
1856–57	5.90	1870–71	6.30
1857–58	18.50	1871–72	12.80
1858–59	10.20	1872–73	9.60
1859–60	18.60	1873–74	21.20
1860–61	13.70	1874–75	12.40
1861–62	32.00	1875–76	21.80
1862–63	4.50	1876–77	5.30
1863–64	6.20		

The author believes that the influence of the Brückner cycle and the double Wolf cycle are clearly discernible in the estimates made for the period 1850–1877, and that the results seem to forecast the early beginning of a wetter rainfall régime in this region.

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SOLAR OBSERVATIONS

SOLAR RADIATION MEASUREMENTS DURING NOVEMBER, 1931

By HERBERT H. KIMBALL, in charge, solar radiation investigations

For a description of instruments employed and their exposures, the reader is referred to the January, 1931, REVIEW, page 41.

Table 1 shows that solar radiation intensities averaged above the normal values for November at Madison and slightly below normal at Washington and Lincoln

Table 2 shows an excess in the total solar radiation received on a horizontal surface at Chicago, New York, and Fresno as compared with November normals for the respective stations; close to normal at Pittsburgh, La Jolla, and Miami; and a deficit at Washington, Madison, Lincoln, Gainesville, and Twin Falls.

Skylight polarization measurements made on 4 days at Washington give 60 for the mean percentage of polarization, with a maximum of 66 per cent on the twenty-fourth. At Madison, polarization measurements made on 4 days give a mean of 72 per cent with a maximum of 75 per cent on the fifth. These are above the corresponding averages for each station in November.

Data received too late to be included in Table 2 for October.

Gainesville, Fla., weeks beginning, October	1	8	15	22
Weekly averages of solar radiation, gr. cal. min. cm^{-2}	307	308	403	354
Departures from normal values	−92	−88	−8	−46

TABLE 1.—*Solar radiation intensities during November, 1931*

[Gram-calories per minute per square centimeter of normal surface]

Washington, D. C.

Date	Sun's zenith distance: 8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass: A. M.					P. M.				Local mean solar time
	e.	5.0	4.0	3.0	2.0	[1] 1.0	2.0	3.0	4.0	5.0	e.
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Nov. 3	5.56				1.24						3.96
Nov. 4	5.16	0.87	1.07	1.24	1.36	1.49	1.34	1.15	1.00	0.85	3.45
Nov. 5	5.36			1.01	1.25				0.84		4.17
Nov. 10	6.27		0.38	0.51	0.79		0.80				7.57
Nov. 23	8.81			0.78	1.12			0.95	0.81	0.66	12.24
Nov. 24	8.81			0.92	1.26		1.28				9.14
Means		(0.87)	(0.73)	0.89	1.17	(1.49)	1.14	(1.05)	(0.88)	(0.76)	
Departures		+0.11	−0.14	−0.11	−0.01		−0.03	+0.06	+0.04	+0.03	

Madison, Wis.

Nov. 3	6.76							1.24			5.56
Nov. 4	3.99	0.92	1.08	1.22	1.36						3.30
Nov. 5	3.63	0.98	1.11	1.31	1.42						3.81
Nov. 13	4.37		1.06	1.14	1.35						3.81
Nov. 18	4.57		0.96	1.10	1.32						5.36
Nov. 22	4.95				1.19						7.29
Means		(0.95)	1.05	1.19	1.33			(1.24)			
Departures		+0.07	+0.04	+0.04	+0.04			+0.10			

Lincoln, Nebr.

Nov. 2	4.95	0.83	0.96	1.11	1.31	1.54	1.31	1.13	1.00	0.86	6.76
Nov. 4	3.81		0.68	0.89	1.26						3.81
Nov. 5	3.81							1.27	1.14	0.99	2.87
Nov. 6	5.16		1.00	1.08	1.24						3.99
Nov. 7	4.75	0.78	0.86	0.99							6.50
Nov. 18	2.49		1.00	1.11							5.79
Nov. 24	2.87	1.03	1.15								2.36
Nov. 25		0.93	1.00	1.16	1.38			1.21	1.10		3.30
Means		0.89	0.95	1.08	1.30		(1.31)	1.20	1.08	(0.92)	
Departures		−0.01	−0.07	−0.11	−0.04		−0.04	+0.01	+0.04	±0.00	

[1] Extrapolated.

TABLE 2.—*Total solar radiation (direct+diffuse) received on a horizontal surface*

[Gram-calories per square centimeter]

AVERAGE DAILY TOTALS

Week beginning—	Washington	Madison	Lincoln	Chicago	New York	Twin Falls	Pittsburgh	Gainesville	Fresno	La Jolla	Miami	Fairbanks
1931	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Oct. 29	185	167	212	149	188	224	156	418	353	293	278	12
Nov. 5	222	178	225	162	235	187	161	295	299	216	375	10
Nov. 12	165	113	179	124	97	172	122	244	251	268	391	10
Nov. 19	182	78	106	112	117	175	119	254	254	301	359	6
Nov. 26	97	137	138	98	89	184	61	162	207	231	328	3
DEPARTURES FROM WEEKLY NORMALS												
Oct. 29	−48	−21	−26	+9	+13	−55	+3	+74	+45	+22	+7	....
Nov. 5	−4	+9	−4	+42	+86	−41	+25	−9	+23	−38	+29	....
Nov. 12	−20	−23	−20	+21	−27	−13	−2	−44	+3	+13	−34	....
Nov. 19	+4	−50	−91	+18	+8	+7	+1	−6	+24	+32	+30	....
Nov. 26	−59	+11	−44	+16	−8	+24	−38	−73	+2	−40	−17	....
Accumulated departures on Dec. 2	−1,577	+2,793	+882	+2,569	+2,394	−5,368	−1,478	....	+1,946	....	....	....

POSITIONS AND AREAS OF SUN SPOTS, NOVEMBER, 1931

[Communicated by Capt. J. F. Hellweg, Superintendent United States Naval Observatory. Data furnished by Naval Observatory, in cooperation with Harvard, Yerkes Perkins, and Mount Wilson observatories. The differences of longitude are measured from central meridian, positive west. The north latitudes are plus. Areas are corrected for foreshortening and are expressed in millionths of sun's visible hemisphere. The total area, including spots and groups, is given for each day in the last column.]

Date	Eastern standard civil time	Heliographic: Diff. long.	Heliographic: Longitude	Heliographic: Latitude	Area: Spot	Area: Group	Total area for each day
1931	*H m*	°	°	°			
Nov. 1 (Naval Observatory)	11 38	No spots					
Nov. 2 (Yerkes Observatory)	14 4	No spots					
Nov. 3 (Naval Observatory)	10 17	No spots					
Nov. 4 (Naval Observatory)	11 57	−39.0	222.4	−0.5		40	
		+56.0	317.4	+8.0		46	86
Nov. 5 (Naval Observatory)	10 10	−26.0	223.2	−0.5		93	
		+68.0	317.2	+7.0		154	247
Nov. 6 (Naval Observatory)	10 36	−12.5	223.3	−0.5		108	
		+80.0	315.8	+8.0		463	571
Nov. 7 (Naval Observatory)	10 23	+2.0	224.7	−0.5		93	93
Nov. 8 (Naval Observatory)	10 58	+16.0	225.2	−0.5		77	77
Nov. 9 (Naval Observatory)	10 51	+26.5	222.6	−1.0		25	25
Nov. 10 (Naval Observatory)	11 29	No spots					
Nov. 11 (Naval Observatory)	11 49	No spots					
Nov. 12 (Naval Observatory)	10 32	No spots					
Nov. 13 (Naval Observatory)	12 55	No spots					
Nov. 14 (Naval Observatory)	13 34	No spots					
Nov. 15 (Naval Observatory)	10 57	No spots					
Nov. 16 (Naval Observatory)	10 13	No spots					
Nov. 17 (Naval Observatory)	14 20	+18.5	107.2	+11.0		37	37
Nov. 18 (Naval Observatory)	11 47	+32.0	108.9	+10.5		31	31
Nov. 19 (Perkins Observatory)	11 20	+43.5	107.7	+10.5		62	62
Nov. 20 (Naval Observatory)	10 8	−79.0	332.4	+9.0	247		
		+60.5	111.9	+10.0	46		293
Nov. 21 (Naval Observatory)	10 20	−70.0	328.2	+9.0		463	
		−23.0	15.2	+10.5		31	494
Nov. 22 (Naval Observatory)	13 14	−55.0	328.4	+9.5		463	
		−9.5	13.9	+10.5	15		
		+5.5	28.9	+11.0		37	515
Nov. 23 (Naval Observatory)	10 54	−42.5	329.0	+10.0		401	
		+17.0	28.5	+11.0		31	432
Nov. 24 (Naval Observatory)	10 11	−30.0	328.7	+10.0		401	401
1931							
Nov. 25 (Naval Observatory)	14 12	−53.5	289.8	−1.0	31		
		−14.5	328.8	+10.0		401	432
Nov. 26 (Naval Observatory)	10 45	−21.0	311.0	+12.0		31	
		−2.5	329.5	+9.5		432	463
Nov. 27 (Perkins Observatory)	11 51	−5.5	312.8	+13.5		80	
		0.0	318.3	+9.0	51		
		+10.0	328.3	+10.0		330	461
Nov. 28 (Mount Wilson)	13 0	+7.0	311.4	+12.0		31	
		+25.0	329.4	+10.0		340	371
Nov. 29 (Mount Wilson)	14 20	+19.0	309.6	+13.0		75	
		+38.0	328.6	+10.0		287	362
Nov. 30 (Yerkes Observatory)	10 21	+28.5	308.2	+13.5	14		
		+29.0	308.7	+14.0	3		
		+31.5	311.2	+14.5	6		
		+36.5	316.2	+12.0	3		
		+45.5	325.2	+10.0	190		
		+47.5	327.2	+10.5	7		
		+49.0	328.7	+10.0	19		
		+54.0	333.7	+10.0	334		576
Mean daily area for November							201

PROVISIONAL SUN-SPOT RELATIVE NUMBERS, NOVEMBER, 1931

(Dependent alone on observations at Zurich and its station at Arosa)

[Data furnished through the courtesy of Prof. W. Brunner, University of Zurich, Switzerland]

November, 1931	Relative numbers	November, 1931	Relative numbers	November 1931	Relative numbers
1	8	11	0	21	29
2	14	12	0	22	39
3	Ec 17	13	0	23	33
4	18	14	0	24	
5	24	15		25	44
6		16	0	26	Mbc 42
7	a 13	17	8	27	a 34
8	12	18	14	28	31
9	16	19	10	29	
10	0	20	d 16	30	26

Mean: 26 days=17.2.

a=Passage of an average-sized group through the central meridian.
b=Passage of a large group or spot through the central meridian.
c=New formation of a center of activity: E, on the eastern part of the sun's disk; W, on the western part; M, in the central zone.
d=Entrance of a large or average-sized center of activity on the east limb.

AEROLOGICAL OBSERVATIONS

[The Aerological Division, W. R. GREGG, in charge]

By L. T. SAMUELS

In Table 1 are shown the mean monthly free-air temperatures and relative humidities. While normals are not available at all of these stations, the means in such cases were compared with the normals of near-by aerological stations. The temperature departures were positive in all cases with the largest values occurring at Cleveland. Relative humidities were above normal at all levels at Dallas and Due West and at the lower levels at Cleveland, Chicago, and Omaha and below normal elsewhere.

At and below the 1,000-meter level the monthly resultant winds contained a greater southerly component than normal over a large portion of the southern and central part of the country. (Table 2.) Over New England the resultant velocities were mostly above normal. At 3,000 meters the monthly resultants were close to the normal values at all stations except in the extreme northwest and southeast. In the former region the monthly resultant direction was northerly as compared to a normal westerly and in the latter region this direction was easterly as compared to a normal northerly. In most cases the resultant velocities were less than normal.

In Table 3 are shown the mean and extreme heights reached during the month. Three airplane observations were missed during the month at Omaha and one at Chicago, due to unfavorable weather conditions.

TABLE 1.—*Mean free-air temperatures and humidities obtained by airplanes (or kites) during November, 1931*

TEMPERATURE (°C.)

Altitude (meters) m. s. l.	Chicago, Ill.[1] (190 meters)	Cleveland, Ohio[1] (245 meters)	Dallas, Tex.[1] (149 meters)	Due West, S. C.[1] (217 meters)	Ellendale, N. Dak.[1] (444 meters)	Hampton Roads, Va.[1] (3 meters)	Omaha, Nebr.[1] (299 meters)	Pensacola, Fla.[3] (2 meters)	San Diego, Calif.[3] (9 meters)
Surface	7.4	7.4	12.9	11.7	−0.4	12.2	4.6	16.8	16.7
500	7.3	7.7	14.1	12.9	0.0	14.4	5.3	17.3	13.8
1,000	6.5	7.2	13.2	12.2	1.6	11.7	6.5	14.9	12.1
1,500	4.2	5.1	11.9	9.6	1.0	------	5.5	------	------
2,000	2.8	3.4	9.8	7.8	−0.9	5.0	4.3	10.9	6.9
2,500	0.8	1.6	7.3	6.1	−3.5	------	2.5	------	------
3,000	−1.7	−0.7	5.2	4.4	−5.9	1.7	−0.5	6.9	1.0
4,000	−6.5	−5.0	−0.6	−1.2	−11.1	------	−6.9	------	------
5,000	−11.5	−9.8	−7.5	------	−17.1	------	−13.7	------	------
6,000	------	−17.2	−15.7	------	------	------	−21.1	------	------

RELATIVE HUMIDITY (PER CENT)

Surface	83	78	84	76	78	81	82	86	58
500	75	74	75	69	76	62	75	77	58
1,000	69	70	68	65	63	60	62	72	47
1,500	61	67	65	64	56	------	55	------	------
2,000	51	55	64	62	52	55	46	59	33
2,500	45	49	60	52	54	------	40	------	------
3,000	44	46	49	45	55	23	41	48	31
4,000	36	36	44	41	62	------	39	------	------
5,000	33	30	41	------	80	------	36	------	------
6,000	------	20	79	------	------	------	35	------	------

[1] Airplanes (Weather Bureau). [2] Kites. [3] Airplanes (Navy).

TABLE 2.—*Free-air resultant winds (meters per second) based on pilot balloon observations made near 7 a. m (E. S. T.) during November, 1931*

Altitude (meters) m. s. l.	Albuquerque, N. Mex. (1,528 meters)		Brownsville, Tex. (12 meters)		Burlington, Vt. (132 meters)		Cheyenne, Wyo. (1,873 meters)		Chicago, Ill. (198 meters)		Cleveland, Ohio (245 meters)		Dallas, Tex. (154 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Havre, Mont. (762 meters)		Jacksonville, Fla. (14 meters)		Key West, Fla. (11 meters)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°	
Surface	N 10 E	0.3	S 43 E	1.1	S 29 W	2.5	N 76 W	4.5	S 48 W	3.1	S 24 W	3.0	S 29 E	2.2	N 33 E	0.9	N 53 W	1.8	S 61 W	2.6	N 6 W	1.7	N 49 E	3.8
500	------	----	S 29 E	8.7	S 39 W	7.4	------	----	S 69 W	7.4	S 57 W	8.4	S 2 W	6.7	N 16 E	0.2	N 64 W	2.1	------	----	N 60 E	5.5	N 66 E	11.3
1,000	------	----	S 23 E	10.3	S 70 W	7.1	------	----	S 80 W	10.5	S 72 W	10.1	S 34 W	6.9	S 31 W	1.2	N 79 W	4.6	S 66 W	5.0	N 76 E	4.2	S 78 E	10.4
1,500	------	----	S 13 E	8.2	S 89 W	9.9	------	----	S 82 W	10.5	S 78 W	10.9	S 58 W	7.0	S 73 W	1.7	N 73 W	6.1	S 83 W	6.6	N 87 E	3.1	N 80 E	9.0
2,000	S 43 W	1.8	S	5.8	N 87 W	10.5	N 80 W	6.2	S 80 W	10.6	S 86 W	11.6	S 72 W	6.4	N 80 W	3.2	N 71 W	8.6	N 82 W	9.0	N 3 E	2.4	N 70 E	8.6
2,500	S 64 W	3.9	S 2 E	4.7	N 89 W	9.8	N 68 W	8.9	------	----	N 89 W	12.3	S 65 W	6.6	N 74 W	4.0	N 73 W	10.3	N 81 W	10.4	N 18 W	2.8	N 76 E	7.3
3,000	S 72 W	5.5	S	2.1	S 83 W	11.3	N 80 W	6.2	------	----	------	----	S 61 W	7.2	N 77 W	4.6	N 72 W	11.9	N 72 W	9.7	N 42 W	6.0	N 73 E	7.1
4,000	S 64 W	9.4	S 26 E	1.3	------	----	W	7.7	------	----	------	----	S 79 W	9.7	N 69 W	7.4	------	----	N 82 W	13.8	N 70 W	10.4	N 24 E	5.7
5,000	S 76 W	9.6	S 47 W	0.7	------	----	S 83 W	10.4	------	----	------	----	------	----	N 59 W	9.7	------	----	------	----	------	----	------	----

Altitude (meters) m. s. l.	Los Angeles, Calif. (217 meters)		Medford, Oreg. (410 meters)		Memphis, Tenn. (89 meters)		New Orleans, La. (25 meters)		Oakland, Calif. (8 meters)		Oklahoma City, Okla. (392 meters)		Omaha, Nebr. (299 meters)		Phoenix, Ariz. (356 meters)		Salt Lake City, Utah (1,294 meters)		Sault Ste. Marie, Mich. (198 meters)		Seattle, Wash. (14 meters)		Washington, D. C. (10 meters)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°	
Surface	N 35 W	0.4	S 11 E	0.1	S 13 E	1.5	N 86 E	1.6	N 41 E	1.9	S 10 W	1.8	S 4 W	0.7	N 87 E	2.3	S 20 E	3.0	S 65 W	1.3	S 43 E	1.7	S 20 W	0.8
500	N 43 E	1.3	N 8 E	0.3	S 14 W	6.1	S 48 E	7.0	N 2 E	3.7	S 15 W	4.2	S 58 W	2.6	S 86 E	2.6	------	----	S 75 W	5.8	S 23 W	3.1	S 84 W	5.9
1,000	N 62 E	1.8	S 7 W	0.9	S 43 W	5.4	S 45 E	4.4	N 5 W	5.3	S 51 W	8.2	S 87 W	7.2	S 69 E	1.7	------	----	N 83 W	9.5	S 20 W	3.5	N 73 W	6.7
1,500	N 43 E	2.5	S 35 W	2.9	S 46 W	5.9	S 46 E	2.0	N 12 W	6.2	S 62 W	7.5	S 87 W	8.6	S 4 E	1.4	S 8 E	4.7	N 59 W	9.3	S 75 W	1.3	N 70 W	9.0
2,000	N 4 W	3.4	S 78 W	3.5	S 75 W	3.0	N 45 E	1.3	N 11 W	5.7	S 59 W	7.8	N 83 W	9.4	S 27 W	2.2	S 19 W	3.6	N 70 W	9.7	N 1 E	2.5	N 67 W	9.6
2,500	N 29 W	3.4	N 67 W	3.1	S 65 W	3.8	S 62 E	0.5	N 7 W	7.5	S 63 W	7.5	N 89 W	9.4	S 74 W	2.9	S 48 W	2.7	------	----	N 8 W	3.7	N 72 W	10.6
3,000	N 48 W	4.5	N 57 W	3.5	S 48 W	5.4	S 85 W	3.5	N 14 W	8.6	S 62 W	7.7	N 79 W	8.8	S 66 W	3.0	S 76 W	2.7	------	----	N 9 W	4.5	N 76 W	12.0
4,000	------	----	N 32 W	4.4	------	----	------	----	N 21 W	8.4	N 87 W	7.1	N 82 W	8.4	S 46 W	3.0	N 68 W	3.2	------	----	------	----	------	----
5,000	------	----	------	----	------	----	------	----	------	----	------	----	------	----	------	----	N 59 W	3.4	------	----	------	----	------	----

TABLE 3.—*Observations by means of airplanes, kites, captive and limited-height sounding balloons during November, 1931*

	Dallas, Tex.[1]	Due West, S. C.[2]	Ellendale, N. Dak.[2]	Chicago, Ill.[1]	Cleveland, Ohio[1]	Omaha, Nebr.[1]
Mean altitudes, meters, m. s. l., reached	5,476	2,616	2,970	4,603	5,526	6,208
Maximum altitude, meters, m. s. l., reached	6,018	4,692	5,069	5,110	6,018	6,793
Number of flights made	30	30	27	29	30	27
Number of days on which flights were made	30	30	26	29	30	27

[1] Airplanes. [2] Kite.

WEATHER IN THE UNITED STATES

[Climatological Division, OLIVER L. FASSIG, in Charge]

THE WEATHER ELEMENTS

By M. C. BENNETT

GENERAL SUMMARY

The weather during November was abnormally warm in most sections from New England westward to the Great Plains. In the more southern States the temperature averaged from 4° to 7° above the normal while in the Great Plains it was only slightly above. On the other hand, from the Rocky Mountain region to the Pacific coast subnormal temperature prevailed, although the departures were but a few degrees below the seasonal average.

The precipitation for the month was abnormally heavy throughout much of the upper Mississippi and lower Missouri Valleys, with an area including central and western Iowa, northwestern Missouri, eastern Kansas, and central Oklahoma reporting from four to five times the normal. Likewise portions of southern Arizona received nearly five times their normal. On the other hand, portions of the Southeast and Northwest received no appreciable precipitation during the month, and portions of the Eastern States from New England to Alabama received less than 25 per cent of the seasonal average; also southern and western Texas and portions of the northern Great Plains, the Pacific Northwest, and northern California received subnormal amounts. Snowfall was moderately heavy over the Rocky Mountain region, but only slight amounts were reported to the eastward.

TEMPERATURE

The first week was generally cool in the eastern and south-central portions, but warm elsewhere, being particularly warm compared with normal in the middle and northern Plains, Rocky Mountain, and Plateau States. From the beginning of the second week till the 24th, decided warmth for November prevailed in the eastern half of the country, and until about the 17th the Plains States and New Mexico usually had warm weather. In the central valleys and to northeastward over the upper Ohio Valley and most of the Lake region the warmth was beyond precedent at this time of year, the departure from normal being about 20°.

Much colder weather set in over most of the Rocky Mountain and Plateau States about the middle of the month, and the Plains States and nearly all of the Mississippi Valley gradually came under its influence as the final decade passed; but the South Atlantic and East Gulf States remained warmer than normal. The last ten days of November were remarkably cold in Montana, Idaho, Utah and large portions of adjoining States.

November averaged colder than normal near and to the westward of the Rocky Mountains, notably in the northern and middle Plateau region and the interior counties of the Pacific States, where it was 4° to 6° colder than normal.

At Eureka, Calif., and Boise, Idaho, this was the coldest or almost the coldest November of record. Some stations in southern California and Montana reported it the first month with mean temperature below normal since the fall of 1930.

Between the western Plains and the Mississippi River, likewise in the Florida Peninsula, this month was moderately to considerably warmer than normal. East of the Mississippi River, save in the Florida Peninsula, this month was almost invariably the warmest November of record. From Tennessee and Missouri northeastward over the Lake region the month averaged 8° to 11° above normal.

The highest marks of several Southwestern States were above 95°. In most States they were in the 80's, but in the majority of northern border States between 75° and 80°. To the westward of the Mississippi River they almost invariably occurred not later than the 8th, but to the eastward usually just before the middle of the month or about the 22d.

The lowest temperatures of the far Western States were considerably below zero, one elevated station in Colorado reporting −41°. In the northern Plains and Minnesota they were several degrees below zero, but in and to the eastward of the middle and lower Mississippi Valley they were mainly between 14° and freezing. In the southeastern quarter of the country the 7th was, as a rule, the coldest day; otherwise the lowest readings occurred almost always on some day of the last decade of the month.

PRECIPITATION

The first decade was a period of decidedly little precipitation, although the North Pacific States were favored. The middle decade and the first half of the last decade brought important precipitation to considerable portions of the Pacific and Plateau regions, also to most of the Plains, the Mississippi Valley, and the upper Lake region, the amounts being notably large in Iowa, Wisconsin and the northern parts of Missouri and Illinois, also considerable portions of Kansas and Oklahoma.

The last few days of November saw somewhat better distribution of precipitation. Moderate to locally heavy falls occurred almost throughout the Ohio and lower Mississippi Valleys and eastern Texas. There continued, however, to be very little rainfall, or locally none at all, in most of Georgia and large parts of the Carolinas, northern Florida, and southeastern Alabama.

The month brought more ample precipitation than the earlier fall months, except near the Atlantic and east Gulf coasts and in a few small areas elsewhere. There usually was moderately less than normal, however, near the Appalachian crest and for a few hundred miles or more to the northwestward, and in the lower Lake region, southern Mississippi and adjacent areas, central and southwestern Texas, the Black Hills region, and the western half of North Dakota. In the Pacific Northwest amounts often were somewhat less than normal.

There was generally a moderate excess above normal in Colorado, New Mexico, Arizona, southern California, the northern Plateau region, and from the eastern parts of the Dakotas to the upper Lake region. At Phoenix, Ariz., the rainfall was 3.18 inches, nearly five times the normal, and with one exception the greatest November amount ever known there.

Rainfall was decidedly heavy for late fall from central Oklahoma northeastward to Iowa, most stations measuring from four to six times their November normal quantities, and exceeding, often by 1 or 2 inches, the previous greatest November precipitation of the locality. As far southwestward as the northwestern part of Texas, and as far eastward as Arkansas, the lower Ohio Valley,

western Indiana, and the vicinity of Lake Michigan there was considerably greater precipitation than normal.

As an indication of the plentiful water supply in recent months over the north-central part of the country, the river stage at St. Louis, Mo., may be noted. On November 30 this reached 22 feet, which was 8 feet below flood stage, but was higher than any previous stage since the latter part of June, 1929.

SNOWFALL

There was practically no snowfall anywhere during the first decade. The middle decade brought a little snow in the northernmost districts from central North Dakota to the western end of Lake Superior and considerable over most of the northern Plateau region, 12 inches falling at Salt Lake City, Utah. During the final decade snowfall occurred in most districts where it is expected by the end of November, though scarcely any fell to the southward of the northern boundaries of Arkansas, Kentucky, and the Virginias. From the lower Missouri Valley to New Jersey a narrow strip received from 2 to 6 or 7 inches about the 26–27th. However, several districts farther northward, particularly large portions of Wisconsin and lower Michigan, received no measurable snow before November ended and most of the Lake region and northern New England had far less than normal.

Most of the Plateau region received snowfall during the closing decade, and some districts a short distance to the eastward of the Divide had unseasonably heavy falls, Denver, Colo., recording almost 15 inches and El Paso, Tex., over 2 inches.

The month's total snowfall was usually less than normal in the eastern half of the country, except moderately above normal from Indiana to New Jersey. In the Plains States and to the westward it was mainly greater than normal. In Idaho the average fall was larger than in any previous November of record, and the records were approached in Utah, Arizona, and New Mexico.

SUNSHINE AND RELATIVE HUMIDITY

The sunshine during November was slightly above the normal locally in the Southeast, the northern Great Plains, the Lower Lakes, and north Pacific areas. Elsewhere it was below the seasonal average, the deficiency being rather pronounced in portions of the upper and central Mississippi and lower Missouri valleys and the central Great Plains.

The relative humidity during the month was generally above the normal from the Plateau and Rocky Mountain regions eastward, except in portions of the southeast and northwest, and locally in the Lake region, where the average was as a rule slightly below. Throughout the Pacific States the humidity was generally below the normal although the departures were small, for the most part.

SEVERE LOCAL STORMS, NOVEMBER, 1931

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A revised list of tornadoes will appear in the Annual Report of the Chief of Bureau]

Place	Date	Time	Width of path (yards)	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Mapleplain, Minn. (vicinity of).	16	9:35 p. m.			$12,000	Tornado	Some farm buildings totally demolished or badly damaged; telephone poles leveled for half a mile; path 5 miles long.	Official U. S. Weather Bureau.
Lindale (near), Tex	17	5 a. m.	200		3,500	do	Buildings damaged at Thedford Switch	Do.
Longview, Tex	17	6 a. m.				Wind	8 oil derricks blown down in Spring Hill community.	Do.
Ludington, Mich	20	11:30–2:40 p. m.				do	Poles and overhead wires damaged; 1 person injured.	Do.
Charles City, Iowa, and vicinity.	20	2:14 p. m.			15,000	Thunderstorm and wind.	Airplane wrecked and another damaged; garage unroofed; buildings on 7 farms damaged.	Do.
Trempeleau County, Wis.	20	4 p. m.			15,500	Squall winds	Schoolhouse and several small buildings wrecked, others damaged; livestock killed.	Do.
Winnsboro (near), La	20					2 small tornadoes	Some small buildings demolished, several others damaged; poultry and pigs killed.	Do.
Santa Fe, N. Mex., and vicinity.	21–22				1,000	Wind	Signs, roofs, awnings, and outbuildings damaged.	Do.
Catron, Valencia, McKinley, San Juan, Rio Arriba and Sandoval Counties, N. Mex.	21–23			9	50,000	Snow, wind, and cold.	Many Indians badly frozen; thousands of sheep lost.	Do.
Amarillo, Tex	22					Rime	Much damage to telephone and light wires	Do.
Barton, Rush, and Ness Counties, Kans.	22–23				10,000	Sleet and glaze	157 poles broken down; 1,000 breaks in wires; power and telephone service greatly hampered.	Do.
Butler, Polk, York, and Fillmore Counties, Nebr.	22–23				80,000	Ice	Considerable injuries to trees and overhead wires.	Do.
Monroe, Audubon, Mahaska, Wapello, Fremont, Mills, and Pottawattamie Counties, Iowa.	22–23					Heavy rains and floods.	Considerable damage to crops, especially unhusked corn, by inundating of farm lands; fences and wooden bridges damaged.	Do.

RIVERS AND FLOODS

By MONTROSE W. HAYES

[In charge River and Flood Division]

Rains in the latter half of November caused moderate floods in the Illinois, the Des Moines, the Missouri River below Kansas City, the Osage, the Neosho, and Verdigris in Kansas, and the Long Tom, a tributary of the Willamette, in Oregon. There was also an overflow in the Delaware, a small stream tributary to the Kansas River.

In the Grand River of Missouri there was a moderately high flood, which caused a severe loss to unhoused crops.

The following is a statement of flood losses:

Tangible property totally or partially destroyed (buildings, fences, highways, bridges, railroads, etc.):	
Grand River	$56,000
Osage River	7,500
Verdigris River	500
Neosho River	500
Total	64,500
Matured crops:	
Illinois River	10,000
Grand River (in Missouri)	636,000
Osage River	5,600
Missouri River below Kansas City	14,000
Neosho River	1,000
Total	666,600
Prospective crops: Neosho River	500
Livestock and other movable property:	
Osage River	1,000
Neosho River	300
Total	1,300
Suspension of business, including wages of employees:	
Osage River	2,000
Neosho River	500
Total	2,500

A complete report on the extent of the Des Moines River flood has not been received. It will appear in the December issue of the REVIEW.

The money value of property saved by warnings was estimated at $25,000 in the Grand Valley, $7,000 in the Osage Valley, and $5,000 in the lower Missouri Valley.

Table of flood stages in November, 1931

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
MISSISSIPPI SYSTEM					
Upper Mississippi Basin					
	Feet			*Feet*	
Raccoon: Van Meter, Iowa	13	24	24	14.2	24
Des Moines: Ottumwa, Iowa	10	24	29	12.2	26-27
Illinois:					
Morris, Ill.	13	23	23	13.3	23
Peru, Ill.	14	22	(1)	17.5	24
Henry, Ill.	10	26	30	10.1	27-28
Havana, Ill.	14	29	(1)	14.0	29-30
Missouri Basin					
Thompson Fork: Trenton, Mo.	20	24	24	20.4	24
Grand:					
Gallatin, Mo.	20	14	19	29.3	16
		23	27	32.6	26
Chillicothe, Mo.	18	15	21	28.3	17
		23	28	29.8	25
Brunswick, Mo.	12	18	(1)	18.9	27
Osage:					
Quenemo, Kans.	30	24	25	34.6	24
Ottawa, Kans.	24	24	26	27.2	25
La Cygne, Kans.	23	25	28	24.1	28
Missouri:					
Boonville, Mo.	21	28	29	21.4	28
St. Charles, Mo.	25	29	30	26.1	30
Arkansas Basin					
Verdigris: Independence, Kans.	30	24	26	36.2	25
Neosho:					
LeRoy, Kans.	24	24	24	25.4	24
Iola, Kans.	15	24	26	16.4	24
Chanute, Kans.	20	24	27	23.0	26
Parsons, Kans.	22	26	28	23.0	28
Oswego, Kans.	17	25	29	19.7	28
PACIFIC SLOPE DRAINAGE					
Columbia Basin					
Long Tom: Monroe, Oreg.	8	22	22	11.1	22

[1] Continued into December.

WEATHER OF THE ATLANTIC AND PACIFIC OCEANS

[By the Marine Division, W. F. MCDONALD in charge]

NORTH ATLANTIC OCEAN

By W. F. MCDONALD

The pressure situation.—The weather of November, 1931, on the North Atlantic Ocean was characterized by an unusually deep and persistent Icelandic LOW, with barometric averages near or somewhat above the November normal over most of the region south of latitude 40°. Highest pressures were central over the American coast northward to Halifax, where the barometer averaged 0.10 to 0.15 inch above normal. From Ireland to Iceland, the average pressure was nearly a half inch below normal, and on more than half the days in the month the minimum barometric readings on the northeastern Atlantic were below 29 inches. There was a slight deficiency in the mean pressure in the Caribbean area.

Table 1 gives details of average pressures, departures from normal, and maxima and minima for a number of coastal and island stations representative of the North Atlantic region.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure (sea level) at selected stations for the North Atlantic Ocean and its shores, November, 1931*

Stations	Average pressure	Departure	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Julianehaab, Greenland [1]	29.49		30.14	19th	28.90	27th.
Reykjavik, Iceland [1]	29.12	−0.50	29.71	30th	28.58	14th.
Lerwick, Shetland Isles [1]	29.60	−0.10	30.39	16th	28.49	10th.
Valentia, Ireland [1]	29.59	−0.45	30.34	30th	28.46	10th.
Lisbon, Portugal [1]	30.08	+0.04	30.26	28th	29.78	12th.
Madeira [1]	30.08	+0.07	30.24	27th	29.88	14th.
Horta, Azores [1]	30.14	+0.01	30.44	19th	29.94	13th.
Belle Isle, Newfoundland [1]	29.83	−0.05	30.64	20th	28.82	14th.
Halifax, Nova Scotia [1]	30.10	+0.15	30.56	20th	29.50	4th.
Nantucket [2]	30.17	+0.12	30.58	27th	29.66	30th.
Hatteras [2]	30.23	+0.12	30.52	26th	29.96	30th.
Bermuda [1]	30.15	+0.07	30.36	20th	29.90	10th.
Turks Island [1]	29.97	−0.02	30.08	27th	29.82	8th.
Key West [2]	30.04	+0.02	30.17	11th	29.90	30th.
New Orleans [2]	30.14	+0.04	30.38	2d	29.86	17th.
Cape Gracias, Nic. [1]	29.84	−0.06	29.94	27th	29.76	14th.

[1] All data based on a. m. observations only, with departure computed from best available normals related to time of observation.

[2] Corrected 24-hour means, based on more than one observation daily.

Great pressure contrasts and active disturbances marked the first half of the month. The period from the 7th to the 10th was stormiest, and on the 9th the LOW in the northeastern Atlantic attained its maximum development, with a central isobar of 28.2 inches clearly identified in the data reported. At the same time a well defined HIGH was present on the American coast, so that a pressure gradient of more than two inches existed between the Grand Banks and the northeastern Atlantic. The situations of the four days November 7 to 10 inclusive, have been chosen for reproduction as Charts VIII to XI, appended to this issue of the REVIEW.

The latter part of the month was, in general, more equable, but was not without several short periods of rather active disturbance. The storm developments of this period arose in several instances well southward in the Atlantic, one being a small but clearly identifiable depression appearing on the 21st southwest of the Azores, and another a similar disturbance, reaching its full development about the 23d, southwest of Bermuda. Both of these LOWS moved northward to unite with more extensive depressions over the northern Atlantic.

Gales and tropical disturbances.—As might have been expected from the general pressure situation outlined above, the stormiest part of the Atlantic during November was north of latitude 45° and east of longitude 30°, in the region which was most persistently under the influence of deep barometric depressions. However, gales occurred on a few days in other areas westward to the Grand Banks, and thence southwestward toward the Bahamas.

The stormiest days on the main trans-Atlantic routes were the 3d and the 7th to the 10th and the 13th to the 15th, inclusive. Winds of whole gale force were reported at places along the routes on each of those days, and hurricane force was encountered by the German ship *New York*, westbound near longitude 25°, on the night of the 8th, and also by the Belgian steamer *Emanuel Nobel*, eastbound on the 13th, in the same area. A number of liners reported delays in crossing due to the heavy weather of this period. A British schooner of 190 tons had to be abandoned by her crew of seven on November 17th in mid-Atlantic due to the long continued storminess of the preceding weeks.

At the beginning of the month a mild disturbance over the western Carribbean Sea produced a distinctive cyclonic circulation which was reported of gale force on the 2d by the Panamanian ship *San Blas*, but the disturbance failed to develop a definite center of low pressure. About a week later, another gale was experienced in the western Caribbean, and news dispatches reported extraordinary rains and storm damage in Honduras, but these appear to have been due to an intensification of the trade winds rather than to a true tropical disturbance.

Fog.—November was almost entirely free from fog over most of the Atlantic, Gulf, and Caribbean waters. Practically all fog reports at hand were received from the region adjacent to the American east coast north of Hatteras, where fogginess was experienced on 5 to 10 days, mainly during the latter half of the month.

OCEAN GALES AND STORMS, NOVEMBER, 1931

Vessel	Voyage		Position at time of lowest barometer		Gale began	Time of lowest barometer	Gale ended	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Highest force of wind and direction	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
NORTH ATLANTIC OCEAN			° ′	° ′				*Inches*					
San Blas, Pan. S. S.	Castilla	Boston	16 40 N	85 30 W	Nov. 1	6 a., 2	Nov. 2	29.78	WSW.	WNW, —.	NW.	WSW, 9	WSW-WNW.
Dresden, Ger. S. S.	Galway	New York	51 11 N	27 01 W	Nov. 3	Noon, 3	Nov. 3	29.04	WNW.	—, 11	WNW.	NW, 11	
Saccarappa, Am. S. S.	Sluiskill	Charleston	47 00 N	13 12 W	Nov. 2	7 a., 3	Nov. 4	29.32	SSW.	SW, 9	W.	SW, 10	SSW-WNW.
Seminole, Br. S. S.	Ellesmere Port.	Baton Rouge.	51 43 N	6 38 W	do	Mdt., 3	do	29.07	S.	SW, 10	W.	SW, 10	SW-W.
Santa Marta, Am. S. S.	Honduras	New York	17 00 N	86 57 W	Nov. 3	4 a., 4	do	29.85	WNW.	NW, 8	N.	NW, 8	WNW-N.
Manistee, Br. S. S.	Liverpool	Jamaica	47 03 N	16 59 W	Nov. 5	8 p., 6	Nov. 9	28.97	S.	WNW, 10.	W.	—, 10	WNW-NW.
Tachira, Am. S. S.	New York	Venezuela	25 41 N	68 48 W	Nov. 7	10 a., 7	Nov. 10	29.78	NE.	NE, 8	ENE.	NE, 9	NE-ENE.
Oranian, Br. S. S.	Halifax	Bristol Channel.	47 21 N	49 47 W	do	8 a., 7	Nov. 7	29.21	W.	W, 3	NNW.	NW, 10	
Emanuel Nobel, Belg. S. S.	Philadelphia.	Manchester	43 55 N	45 22 W	Nov. 8	Mdt., 8	Nov. 9	29.57	NW.	NW, 10	NW.	—, 10	NW-NNW.
Brabeholm, Swed. S. S.	Newcastle-on-Tyne.	Portland, Me.	55 20 N	29 54 W	do	10 p., 8	Nov. 10	28.22	SE.	NE, 4	NW.	NW, 11	NE-N.
New York, Ger. S. S.	Cherbourg	New York	49 00 N	24 42 W	do	2 p., 8	do	28.74	S.	—, 10	NW.	—, 12	S-W-NW.
Kattegat, Ger. M. S.	Batum	Hamburg	46 40 N	6 31 W	Nov. 5	—, 8	Nov. 8	28.92	WSW.	W, 8	N.	WSW, 10.	W-NW.
Southern Prince, Br. M. S.	New York	Rio de Janeiro.	30 44 N	60 57 W	Nov. 8	4 a., 9	Nov. 9	29.77	ENE.	NE, 9	SSE.	NE, 9	NE-SE.
Carlier, Belg. S. S.	Antwerp	New York	49 20 N	21 10 W	do	2 p., 9	Nov. 10	29.09	WSW.	W, 11	WNW.	NW, 11	WSW-WNW.
Clairton, Am. S. S.	New York	Manchester	50 50 N	17 00 W	Nov. 7	4 a., 10	do	28.66	SSW.	W, 7	W.	W, 10	SSW-W.
Vincent, Am. S. S.	New York	Havre	48 25 N	11 02 W	Nov. 9	4 a., 10	Nov. 11	28.85	WSW.	WSW, 10.	WSW.	WSW, 10.	Steady.
Wytheville, Am. S. S.	Rotterdam	Boston	50 55 N	21 50 W	Nov. 12	5 a., 13	Nov. 14	28.78	S.	S, —	W.	W, 10	S-SW-W.
Emanuel Nobel, Belg. S. S.	Philadelphia.	Manchester	50 31 N	21 33 W	Nov. 13	—, 13		28.88	S.	S, 10	W.	SSW, 12	
Europa, Ger. S. S.	Cherbourg	New York	49 17 N	23 14 W	Nov. 12	2 a., 13	Nov. 15	28.87	S.	—, 10	ENE.	WNW, 11.	
Tuscarora, Br. S. S.	Glasgow	Galveston	50 27 N	18 08 W	Nov. 13	7 a., 13	Nov. 14	29.32	SSW.	SSW, 11	S.	—, 11	S-SW-W.
Schenectady, Am. S. S.	Copenhagen	Portland, Me.	58 45 N	8 00 W	do	4 p., 13	Nov. 21	29.19	SSE.	S, 8	NW.	NW, 11	S-SW.
Forthbank, Br. S. S.	New Orleans	Canal Zone	15 38 N	81 15 W	do	4 p., 14	Nov. 14	29.84	ENE.	E, 7	ESE.	E, 9	E-ESE.
West Chatala, Br. S. S.	Galveston	Havre	44 16 N	44 15 W	Nov. 14	11 p., 14	do	29.44	NNW.	SSW, 10	NW.	SSW, 10	SSW-NW.
Aquitania, Br. S. S.	New York	Southampton	41 32 N	56 21 W	Nov. 15	4 p., 15	Nov. 17	30.06	NW.	NW, 8	NW.	NW, 9	NW-NNW.
West Quechee, Am. S. S.	Hamburg	Galveston	40 20 N	22 44 W	Nov. 22	Noon, 22	Nov. 22	29.39	SSE.	NE, 9	NNW.	—, 9	SSE-E-NNW.
Ponce, Am. S. S.	New York	Porto Rico	31 15 N	70 18 W	Nov. 23	8 p., 23	Nov. 24	29.81	E.	E, —	ESE.	ESE, 10	E-ESE.
Prusa, Am. S. S.	Galveston	Barcelona	30 42 N	68 42 W	do	3 p., 23	do	29.90	ENE.	ENE, —.	E.	—, 10	
Gulf Hawk, Am. S. S.	Las Piedras	Philadelphia.	26 19 N	75 16 W	Nov. 24	Noon, 24	do	29.52	SW.	SW, 7	N.	W, 10	SW-W.
City of Hamburg, Am. S. S.	Hamburg	Baltimore	49 04 N	27 03 W	Nov. 22	Noon, 25	Nov. 27	29.24	S.	W, 8	W.	—, 10	W-NW.
Bremen, Ger. S. S.	Cherbourg	New York	47 06 N	37 18 W	Nov. 30	Mdt., 30	Dec. 1	28.98	SSE.	—, 12	NW.	—, 12	
Aden Maru, Jap. S. S.	Fowey, England.	Portland, Me.	46 53 N	38 55 W	Nov. 29	8 p., 3	do	29.15	S.	SW, 11	WNW.	SW, 12	S-SW-WNW.
Bellflower, Am. S. S.	Avonmouth	Baltimore	51 35 N	23 43 W	Nov. 30	3 a., 30	Nov. 30	29.68	SSE.	SSE, 8	NW.	SSE, 10	SSE-NNW.

OCEAN GALES AND STORMS, NOVEMBER, 1931—Continued

Vessel	Voyage From—	Voyage To—	Position at time of lowest barometer Latitude	Position at time of lowest barometer Longitude	Gale began	Time of lowest barometer	Gale ended	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Highest force of wind and direction	Shifts of wind near time of lowest barometer
NORTH PACIFIC OCEAN			° ′	° ′				*Inches*					
Hakushika Maru, Jap. S. S.	Miike	Port Townsend.	49 07 N	154 10 E	Oct. 30	Mdt., 3	Nov. 4	29.33	S	S, 9	S	S, 9	Steady.
Emp. of Asia, Can. S. S.	Vancouver	Yokohama	45 35 N	158 11 E	Nov. 1	2 a., 2	Nov. 2	29.50	SW	W, 8	W	WNW, 10.	SW-W-WNW.
Chief Capilano, Br. S. S.	do	do	48 15 N	166 45 E	Nov. 2	4 p., 2	Nov. 3	29.22	SW	WSW, 10.	NW	W, 11	WSW-W.
Illinois, Am. S. S.	Portland	do	47 03 N	164 10 E	do	1 p., 2	Nov. 4	29.32	S	W, 11	N	W, 11	WSW-W.
Golden Wall, Am. S. S.	Hong Kong	San Francisco	46 09 N	172 30 W	do	1 p., 2	do	29.60	W	WSW, —	WNW	WSW, 9	WSW-W.
Tyndareus, Br. S. S.	Yokohama	Victoria	49 00 N	177 40 W	do	4 p., 4	do	29.06	WSW	WNW, 9	WNW	W, 10	WNW-NW.
Melville Dollar, Am. S. S.	Cebu, P. I.	Los Angeles	39 27 N	140 01 W	do	2 a., 3	do	29.41	NE	N, 10	W	NNE, 11	2 pts.
Satanta, Br. S. S.	Yokohama	San Pedro	44 43 N	178 18 W	do	8 a., 3	Nov. 5	29.37	WNW	W, 10	NW	W, 10	W-WNW.
Soyo Maru, Jap. M. S.	do	San Francisco	47 20 N	167 38 W	do	3 p., 3	do	29.11	W	WSW, 9	W	WSW, 9	WSW-SW.
Alaska, Am. S. S.	Seattle	Seward	Resurrection Bay, Alaska		Nov. 3	3 p., 4	Nov. 4	29.62	S	S, 6		S, 10	Variable.
Bellingham, Am. S. S.	Dairen	San Francisco	47 45 N	177 45 W	do	8 a., 3	Nov. 5	29.04	W	W, 8	NW	W, 9	W-WNW-W.
Ohioan, Am. S. S.	New York	Los Angeles	15 20 N	93 25 W	Nov. 4	4 p., 4	Nov. 4	29.84	NW	NW, 5	NW	N, 9	
Pres. Jefferson, Am. S. S.	Victoria	Yokohama	52 31 N	158 48 W	Nov. 3	4 p., 4	Nov. 7	28.70	SSE	WSW, 5	NW	NW, 8	WSW-W.
Lebec, Am. S. S.	Portland	San Pedro	45 38 N	124 17 W	Nov. 6	—	Nov. 6	29.94	S	S, 7	SSW	S, 8	Steady.
Helen Whittier, Am. S. S.	Balboa	San Francisco	15 00 N	94 10 W	Nov. 8	5 p., 8	Nov. 9	29.87	NNW	NNW, 6	NNW	NNW, 10.	Do.
Stuart Dollar, Am. S. S.	Philippines	Los Angeles	15 15 N	128 00 E	Nov. 9	5 a., 9	do	29.68	NNE	E, 11	S	E, 11	ENE-E.
Hayo Maru, Jap. S. S.	Muroran	William Head	45 06 N	161 43 E	Nov. 10	11 p., 12	Nov. 13	28.55	S	NNW, 10.	SW	WNW, 11.	
Pres. Cleveland, Am. S. S.	Yokohama	Seattle	48 09 N	173 23 E	do	6 p., 12	Nov. 14	29.15	SE	SE, 9	S	SSE, 9	SE-S-WSW.
Tamaha, Br. S. S.	Hong Kong	San Pedro	22 00 N	116 14 E	Nov. 11	6 a., 11	Nov. 11	29.52	ENE	NNE, 10.	SE	NE, 11	NNE-NE.
Melmay, Br. S. S.	Portland	Hankow	34 51 N	154 47 E	do	2 p., 11	Nov. 12	29.73	SSW	NW, 9	NW	NW, 9	SW-NW.
Iowa, Am. S. S.	Japan	San Francisco	41 48 N	179 55 W	do	Noon, 12	do	29.63	S	SE, 7	SE	S, 9	S-SE.
Meigs, Am. S. S.	Manila	do	38 13 N	135 11 W	Nov. 14	6 a., 14	Nov. 14	29.93	NW	NW, 8	NNW	NW, 8	Steady.
Golden River, Am. S. S.	Hong Kong	do	39 13 N	153 06 E	Nov. 17	1 p., 17	Nov. 17	29.59	W	NE, 9	NNE	NE, 9	W-NE.
Akagisan Maru, Jap. M. S.	Yokohama	do	45 57 N	172 23 W	Nov. 18	6 a., 19	Nov. 20	28.37	NE	W, —	SW	WSW, 9	ENE-W-WSW.
Lebec, Am. S. S.	San Pedro	Seattle	40 40 N	124 38 W	Nov. 22	2 p., 22	Nov. 23	29.99	NNW	N, 7	N	N, 8	Steady.
Michigan, Am. S. S.	Tabaco, P. I.	San Francisco	26 00 N	137 20 E	do	8 p., 23	Nov. 24	29.31	ESE	S, 10	NW	S, 10	S-SW.
Stuart Dollar, Am. S. S.	Philippines	Los Angeles	38 30 N	178 30 W	Nov. 23	4 p., 23	do	28.88	SE	SE, 4	NW	NNW, 12	
Defiance, Am. M. S.	Shanghai	San Pedro	31 26 N	133 00 E	do	Mdt., 23	do	29.59	NE	ENE, 11	N	ENE, 11	NE-ENE.
San Luis Maru, Jap. M. S.	Kudamatsu	Los Angeles	39 50 N	164 12 W	do	6 p., 23	do	29.11	SSE	SSE, 9	W	SSE, 9	SSE-S.
Golden River, Am. S. S.	Hong Kong	San Francisco	46 35 N	170 19 W	do	2 p., 25	Nov. 26	29.13	N	S, 11	SW	SSE, 12	SSE-S.
Emp. of Russia, Can. S. S.	Vancouver	Yokohama	52 30 N	157 00 W	Nov. 24	7 p., 24	Nov. 25	29.71	SSE	SE, 9	SW	SE, 9	SE-S.
Do	do	do	52 00 N	168 00 W	Nov. 25	8 a., 25	Nov. 27	28.76	SW	S, 11	SW	S, 11	
Reiyo Maru, Jap. S. S.	Muroran	Juan de Fuca	49 03 N	170 35 W	do	8 p., 25	Nov. 26	28.62	SE	S, 10	SW	SSW, 11	6 pts.
Oregon, Am. S. S.	Otaru	San Francisco	50 25 N	171 30 W	do	8 a., 25	do	28.44	SSE	SE, 11	W	S, 12	SE-S.
Hakubasan Maru, Jap. M. S.	Yokohama	do	45 10 N	175 33 W	do	5 a., 25	Nov. 27	28.63	SSW	SSW, 10	W	SSW, 10	1 pt.
Stuart Dollar, Am. S. S.	Philippines	Los Angeles	38 18 N	152 00 W	Nov. 29	9 p., 29	Nov. 30	30.05	N	N, 8	NNE	N, 10	N-NNE.
Defiance, Am. M. S.	Shanghai	San Pedro	41 24 N	163 30 E	do	3 a., 30	do	29.09	ESE	—, 8	NNW	NW, 11	SSW-W.
Golden Sun, Am. S. S.	Dairen	San Francisco	38 24 N	177 18 W	Nov. 30	Mdt., 30	do	29.77	S	NW, 8	NW	NW, 8	W-NW.
SOUTH ATLANTIC OCEAN													
Maria De Larrinaga, Br. S. S.	England	Nacochea, Argentina.	Nacochea		Nov. 4	1 a., 4	Nov. 4	29.51	SW	SW, —	NNW	SW, 10	SW-W.
Persier, Belg. S. S.	Buenos Aires	Santos	25 54 S	48 38 W	Nov. 7	4 a., 8	Nov. 8	29.43	NE	NNE, 9	NW	NNE, 9	NNE-NW.
Brasilien, Dan. S. S.	Hull	Buenos Aires	31 20 S	48 40 W	Nov. 15	4 a., 16	Nov. 17	29.24	NE	WSW, 10	SW	WSW, 10	NW-W-S.

NORTH PACIFIC OCEAN

By WILLIS E. HURD

Atmospheric pressure, November, 1931.—The average center of the Aleutian LOW in November was far to the westward of its October position, and lay over Bering Sea (St. Paul 29.50 inches, and Dutch Harbor 29.55 inches). At both these stations the pressure averages were below the normal for the month. Winter conditions of pressure, with some extremely great and rapid fluctuations in the barometer from day to day, were common to the whole Aleutian region. Instances of this great pressure variability are shown in the p. m. barometer readings at Dutch Harbor from the 23d to the 27th, which are as follows: 23d, 29.90 inches; 24th, 28.60; 25th, 29.68; 26th, 28.86; 27th, 29.80. Pressures above normal were found along the American coast from Kodiak eastward and southward to Tatoosh Island.

Fairly stable high pressure, with the average crest of the anticyclone over the eastern part of the ocean, prevailed in middle latitudes, while a continuing belt of moderately high pressure extended westward along lower middle latitudes to near the Asiatic coast. Here it expanded to include Japanese waters and the eastern seas of China. As usual to the season, in the Japanese region the anticyclone was considerably broken by the intrusion of frequent LOWS.

The following table gives barometric data for several island and coast stations in west longitudes, including Point Barrow on the Arctic Ocean.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, North Pacific Ocean and adjacent waters, November, 1931, at selected stations*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Point Barrow [1 2]	30.00	+0.01	30.92	13th	29.20	28th.
Dutch Harbor [1]	29.55	−0.04	30.50	12th	28.60	3d.
St. Paul [1 3]	29.50	−0.09	30.40	12th	28.40	3d.
Kodiak [1]	29.68	+0.12	30.36	24th	29.02	5th.
Midway Island [1]	30.05	−0.03	30.24	29th	29.70	17th.
Honolulu [3]	29.99	−0.03	30.12	4th	29.85	26th.
Juneau [3]	29.95	+0.19	30.59	25th	29.20	1st.
Tatoosh Island [3 4]	30.02	+0.05	30.44	21st	29.28	16th.
San Francisco [3 4]	30.05	−0.04	30.38	19th	29.67	14th.
San Diego [3 4]	30.00	−0.02	30.20	19th	29.60	21st.

[1] P. m. observations in averages: a. m. and p. m. in extremes.
[2] For 29 days.
[3] A. m. and p. m. observations.
[4] Corrected to 24-hour mean.

Cyclones and storminess.—November, 1931, may be called a stormy month on the North Pacific. Moderate to intense progressive cyclones, as well as oscillating storms of the Aleutian LOW type, swept upper and middle

latitudes. Typhoons and strong monsoons were felt in the Far East. Locally intensified trades, rising in force to that of a fresh gale, were reported on the 9th to 11th east of the Hawaiian Islands, and on several days Tehuantepecers roughened the weather off the Mexican south coast. But stormiest of all the regions was that lying approximately between latitudes 35° and 53° N., and longitudes 165° W. and 160° E. This region was traversed by most of the principal cyclones of the month.

The earliest northern cyclone of November, coming out of Siberia on the 1st, passed eastward over the Aleutians and entered the American mainland on the 6th. It was attended by fresh to whole westerly gales over an extensive area, involving the main trans-Pacific steamship routes south of the Aleutians, with the highest wind, force 11, on the 2d.

During the 9th to 12th another Siberian cyclone, after crossing the lower Kurils, sped northeastward and entered the Aleutian area. Its effects were experienced by shipping most severely on the 12th, during which day gales of varying forces up to 11 were reported along the upper route between 160° and 175° E.

About the 22d or 23d a storm development, secondary to a disturbance then over the Aleutians, appeared to the northeastward of Midway Island. At first it had a northwesterly trend about the HIGH then overlying the eastern part of the ocean, but by the 24th it was moving nearly north toward the Bering Sea, which it entered on the 26th. During most of its course it was a deep and violent cyclone. The heavy gales associated with it began on the 23d, when the American steamship *Stuart Dollar* encountered a northwesterly hurricane in 38° 30′ N., 178° 30′ W., barometer down to 28.88 inches. On the 25th several vessels experienced wind forces of 11 to 12, among them the American steamship *Oregon*, which encountered a southeast hurricane, with barometer down to 28.44 inches, in 50° 25′ N., 171° 30′ W. The cyclone continued northward with diminishing energy and by the 28th lay over northern Alaska and the adjacent Arctic Ocean.

During the 29th, in about 42° N., 163° E., the American motor ship *Defiance* encountered a northwest gale of force 11 in connection with a moderately deep cyclone, the earlier and subsequent movements of which are as yet little known.

Other gales of forces 8 to 10, not associated with the cyclones already mentioned, occurred at various times over the northern Pacific. They were for the most part connected with the fluctuating activities of the semipermanent Aleutian LOW. On the American coast fresh gales occurred on a few days, due to the proximity of depressions over the western extremity of the continent. The most important of these winds are mentioned in the tabular report of gales and storms.

One further extratropical cyclone needs to be mentioned. It gathered on the 1st of the month near 32° N., 147° W., in the midst of the North Pacific anticyclone. It had a slow northeast progression, but by the 3d, then central near 37° N., 137° W., it had penetrated the high-pressure area and joined the lower extension of the Aleutian cyclone to the northward. Thereafter it quickly lost identity and force, and only a very shallow depression remained of it off the California coast on the 4th. The cyclone attained local violence on the 3d, as may be gathered by the report of the American steamer *Melville Dollar*. which experienced a northerly gale of force 11, barometer down to 29.41 inches, while crossing the LOW near 39° N., 140° W.

Typhoons.—Three November typhoons appear to have formed in the Far East. The first formed about midway between Guam and the Philippines on the 3d or 4th. It crossed central Luzon on the 7th and went westward into the China Sea. We have no present information as to its intensity.

The second typhoon probably formed on the 6th or 7th in much the same locality as had its predecessor. It went northwestward over Luzon and seems to have entered the China coast not far from Hong Kong on the 11th. Reports from two vessels indicate considerable intensity both east and west of the Philippines. On the 9th the American steamer *Stuart Dollar* experienced an east gale of force 11, lowest barometer 29.68, in 15° N., 128° E., and on the 11th the British tanker *Tamaha* encountered this storm as a northeasterly gale of similar force, lowest barometer 29.52, some 130 miles east of Hong Kong.

The third typhoon originated a little west of Guam on the 17th. After a westward movement for two or three days, it turned north, then went northeastward between the Ogasawara Islands and Japan, and disappeared at sea on the 24th near 40° N., 155° E. The American motorship *Defiance* experienced this cyclone as a gale of force 11 on the 23d, in 31° 26′ N., 133° 00′ E.

Northers.—Northers were reported in the Gulf of Tehuantepec from the 1st to the 8th, all of force 7, except on the 4th, when the gale rose to force 9, and on the 8th, when a force of 10 was encountered.

Winds at Honolulu.—The prevailing wind direction at Honolulu was from the east, with a maximum velocity of 24 miles from the east on the 8th.

Fog.—Only three or four days with fog were reported for all that part of the ocean west of 160° W. On the upper and middle routes between 130° and 160° W., scattered fog occurred on nine days, principally between the 19th and the 29th. There was much lessening of fog on the American coast as compared with October; but taking that part of the coast between Capes Mendocino and Conception as a whole, fog occurred on the first eight days of November and on the 20th. In the Gulf of Tehuantepec it was reported on the 16th and 21st near boundary lines of blue and green water.

TYPHOONS OF THE FAR EAST DURING SEPTEMBER AND OCTOBER, 1931

[Abstract of reports furnished by the Rev. MIGUEL SELGA, S. J., director, Weather Bureau, Manila, P. I.]

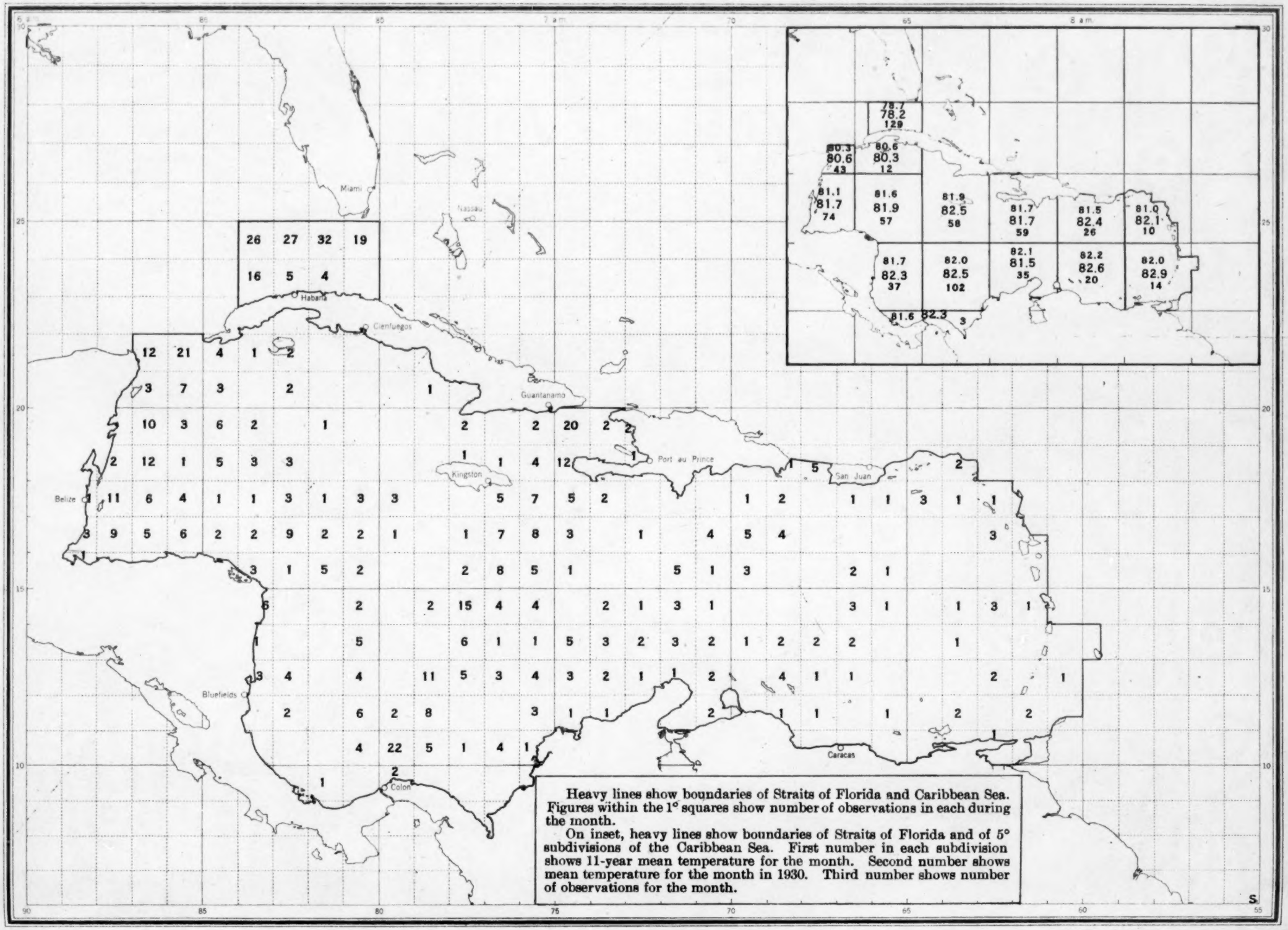
The manuscripts descriptive of the September and October typhoons in the Asiatic section of the North Pacific Ocean, kindly furnished by the Rev. Miguel Selga, S. J., director of the Philippine Weather Bureau, were received too late for inclusion in the September and October issues of the MONTHLY WEATHER REVIEW. Inasmuch as the regular North Pacific weather summaries have already given brief, though necessarily incomplete, mention of the several typhoons of those months, the restrictions of space in the current issue allow only of a brief résumé of the more important details that may be drawn from the articles in hand.

Typhoons of September.—Three typhoons of low latitudes were reported. The first, a very narrow but violent storm of September 1–4, appeared off the southeast China coast in the Taiwan Channel. The second, that of September 9–13, crossed the Eastern and Japan Seas, and disappeared north of Japan. It acquired greatest intensity and progressive velocity with passage of the Chosen (Korea) Strait. The third, that of September

SHIP OF MIGHT

Distribution of Greenwich Mean Noon Bucket Observations of Sea-Surface Temperatures, November, 1930

(Plotted by Giles Slocum)


Miami
Nassau
Habana
Cienfuegos
Guantanamo
Port au Prince
Kingston
San Juan
Belize
Bluefields
Caracas
Colon
78.7 78.2 129
80.3 80.6 43
80.6 80.3 12
81.1 81.7 74
81.6 81.9 57
81.9 82.5 58
81.7 81.7 59
81.5 82.4 26
81.0 82.1 10
81.7 82.3 37
82.0 82.5 102
82.1 81.5 35
82.2 82.6 20
82.0 82.9 14
81.6 82.3 3
Heavy lines show boundaries of Straits of Florida and Caribbean Sea. Figures within the 1° squares show number of observations in each during the month.
On inset, heavy lines show boundaries of Straits of Florida and of 5° subdivisions of the Caribbean Sea. First number in each subdivision shows 11-year mean temperature for the month. Second number shows mean temperature for the month in 1930. Third number shows number of observations for the month.

18–28, was the the severest storm of the month in the lower latitudes of the Far East. It originated east of Samar, and on the 20th and 21st, moving almost due north, crossed Luzon, barely missing Manila. The lowest pressure obtained in the Philippines was 28.80 inches, at Daet, and the highest wind force, 12, from southwest, in Legaspi Bay. The storm was attended by heavy rains. A little south of 30° N. the typhoon track turned northeastward, skirted the western coast line of Japan, and the center then moved rapidly on past Sakhalin Island.

(The report does not mention among the typhoons of the month the very severe cyclone which occurred south and east of Japan from the 8th to 11th.)

Typhoons of October.—Four severe typhoons occurred in October, 1931. The storm of October 5–14 originated south-southwest of Guam, moved northwest, recurved to the northeast, and after crossing central Japan, proceeded into the open sea. "Press dispatches from Tokyo reported torrential rains and terrific winds associated with loss in life in central and western Japan. The typhoon was considered one of the worst to hit Japan in years."

The China Sea typhoon of October 9–11, which was of known hurricane force on the 10th south of Hong Kong, passed almost due west into Indo-China.

The so-called *Taurus* typhoon of October 13–20 originated between Guam and Yap. "Yet," said Father Selga, "no accurate idea of the extent and severity of the typhoon could be formed until the steamer *Taurus*, anchored at port San Vincente, reported a barometric reading of 731 millimeters (28.78 inches) and WSW. winds of force 12 at noon on October 18." The lowest barometer experienced by the *Taurus*, 28.69 inches, occurred a half hour later. The typhoon was then passing western Luzon. It headed into the China Sea, where it disintegrated on the 20th. The accompanying rainfall over northern Luzon was very heavy on the 18th. The total fall in Aparri was nearly 10 inches and gave rise to the severest flood in that region since 1908.

The typhoon of October 20–27 was first indicated as a depression south of Guam. Going northwestward, the storm gathered energy and by the 24th, when about midway between the Philippine and Bonin Islands, it began to recurve into the northeast, attaining hurricane strength for an approximate distance of 100 miles outward from the center. Here it was encountered by the M. S. *Irisbank*, which experienced winds of force 8 to 12 for 44 hours. Near the Bonins (Ogasawara) on the 26th the S. S. *Yoro Maru* was reported in distress and later to have gone ashore on one of the small islands. The *Silverhazel* proceeded to her assistance, but in 29° 25′ N., 143° 20′ E., was forced to heave to in a northwest hurricane (force 12) and in consequence had to abandon her quest. The typhoon was lost to observation on the 27th far to the eastward of Japan.—*W. E. H.*

BUCKET OBSERVATIONS OF SEA-SURFACE TEMPERATURES

By GILES SLOCUM

STRAITS OF FLORIDA AND CARIBBEAN SEA

Table 1 shows the average temperatures for the Caribbean Sea and the Straits of Florida for November of each year from 1919 to 1930, inclusive, and Table 2 summarizes the temperature for November, 1930, in the same areas. The chart shows the number of observations taken in November, 1930, within each 1-degree square and mean temperature data for subdivisions of the area considered.

The surface water of the Caribbean Sea is warmer than the yearly mean throughout November, but autumn conditions are well established by the beginning of the month, and the temperature drop is pronounced thereafter until the end of the year and beyond. Of an annual range in temperature of approximately four and a half degrees, nearly a third of the drop from the peak in September to the minimum in March occurs in November and another third in December.

This temperature drop in the Caribbean is slightly greater in December than in November, but in the Straits the most rapid drop during the year is in November.

November, 1930, was the ninth consecutive month having above-average temperature in the Caribbean Sea, being warmer than the 11-year mean except during the first quarter when the temperature was seasonable. The fall in temperature, as the month progressed, was slower than is usual at this season, and at variance with the relatively rapid normal fall in mean temperature described above.

The Straits of Florida were unseasonably cool during the first half of the month and slightly warmer than the 11-year mean during the second half, the month as a whole being cooler than the average.

TABLE 1.—*Mean sea-surface temperatures in the Caribbean Sea and the Straits of Florida for November, 1919–1930*

Year	Caribbean Sea		Straits of Florida	
	Number of observations	Mean (° F.)	Number of observations	Mean (° F.)
1919 [1]	97	81.2	18	79.3
1920	146	81.5	47	78.2
1921	233	80.8	74	79.1
1922	205	81.8	78	79.6
1923	289	81.3	95	77.0
1924	259	81.7	91	77.2
1925	340	81.8	95	80.2
1926	259	82.3	127	78.5
1927	510	82.4	147	79.2
1928	539	81.8	140	79.3
1929	565	81.4	191	79.2
1930	550	82.0	129	78.2
Mean (1920–1930)	----------	81.7	----------	78.7

[1] Not used in computations because of insufficient data available.

TABLE 2.—*Mean sea-surface temperatures (°F.,) and number of observations, November, 1930*

Quarter	Period	Caribbean Sea				Straits of Florida			
		Number of observations	Mean	Departure from 11-year mean (1920–1930)	Change from preceding month	Number of observations	Mean	Departure from 11-year mean (1920–1930)	Change from preceding month
			° F.	° F.	° F.		° F.	° F.	° F.
I	Nov. 1–7	136	82.1	----------	----------	34	77.8	----------	----------
II	Nov. 8–15	135	82.1	----------	----------	40	78.4	----------	----------
III	Nov. 16–22	132	81.9	----------	----------	23	78.6	----------	----------
IV	Nov. 23–30	147	81.8	----------	----------	32	77.8	----------	----------
	Month	550	82.0	+0.3	−0.9	129	78.2	−0.5	−3.0

CLIMATOLOGICAL TABLES

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, November, 1931

[For description of tables and charts, see REVIEW, January, p. 50]

Section	Temperature								Precipitation					
			Monthly extremes								Greatest monthly		Least monthly	
	Section average	Departure from the normal	Station	Highest	Date	Station	Lowest	Date	Section average	Departure from the normal	Station	Amount	Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	60.8	+6.6	Selma	89	14	3 stations	25	7	1.76	−1.58	Riverton	4.26	Alaga	0.00
Arizona	48.8	−3.9	Granite Reef Dam	100	3	Fort Defiance	−30	24	2.57	+1.76	Natural Bridge	7.72	Yuma (weather bureau)	0.14
Arkansas	57.6	+6.2	2 stations	88	[1] 3	Dutton	18	1	6.34	+2.69	Georgetown	9.19	Portland	2.49
California	47.6	−3.9	Indio	98	3	Madeline	−12	26	2.92	+0.45	Crescent City	10.80	Greenland Ranch	0.02
Colorado	32.5	−2.9	Two Buttes	89	7	Garnett	−41	25	1.40	+0.54	Cumbres	11.45	Wray	0.10
Florida	68.5	+3.3	Venus	90	30	2 stations	30	[1] 2	0.48	−1.70	Fort Lauderdale	3.53	14 stations	0.00
Georgia	60.6	+6.0	Quitman	90	[1] 5	Blairsville	21	7	0.63	−2.10	Dahlonega	4.10	3 stations	0.00
Idaho	30.1	−4.9	Glenns Ferry	81	8	Obsidian	−27	22	1.88	−0.20	Roland	6.57	Aberdeen	0.20
Illinois	51.0	+8.9	Hillsboro	83	8	Sycamore	16	26	4.87	+2.35	2 stations	7.96	Roberts	2.47
Indiana	51.1	+8.9	Rome	83	15	2 stations	16	[1] 26	3.86	+0.76	La Porte	7.56	Bluffton	2.09
Iowa	43.9	+7.3	5 stations	81	8	do	1	29	5.76	+4.21	Guthrie Center	9.00	Inwood (near)	2.86
Kansas	46.2	+2.6	3 stations	87	[1] 7	Tribune	1	25	4.46	+3.11	Sedan	11.19	Richfield	0.15
Kentucky	55.0	+8.6	Williamsburg	84	14	Middlesboro	19	7	3.52	−0.05	Murray	6.61	Louisa	1.04
Louisiana	64.9	+6.0	2 stations	88	[1] 4	2 stations	28	1	4.84	+1.05	Ville Platte	9.98	Port Eads	1.49
Maryland-Delaware	51.8	+6.7	4 stations	80	[1] 12	Oakland, Md	16	7	0.94	−1.61	Sines, Md	2.48	Hancock (city), Md	0.34
Michigan	44.4	+8.0	Bangor	75	[1] 23	Garnet	6	26	3.85	+1.39	Eau Claire	5.75	Palmesdale	0.74
Minnesota	35.8	+6.2	Canby	81	8	Meadowlands	−12	29	2.88	+1.79	Grand Meadow	5.80	Milan	0.73
Mississippi	61.5	+6.3	Austin	89	13	West Point	25	7	4.64	+1.05	Austin	9.22	Leakesville	1.13
Missouri	52.2	+7.8	Jefferson City	87	[1] 8	Maryville	17	25	5.46	+3.06	Kidder	9.72	Shelbina	3.42
Montana	28.6	−3.3	6 stations	77	[1] 1	Ovando	−32	22	0.91	+0.09	Heron	5.21	2 stations	T.
Nebraska	38.4	+1.7	North Loup	89	8	Gordon	−6	26	2.21	+1.42	Syracuse	6.38	Hull (near)	0.19
Nevada	35.9	−4.7	Logandale	91	4	San Jacinto	−15	23	0.98	+0.27	Marlette Lake	3.81	Imlay	0.24
New England	43.7	+5.7	Brockton, Mass	80	10	Garfield, Vt	−1	27	1.33	−2.10	Pittsburg (A), N. H.	3.09	Nashua, N. H	0.64
New Jersey	50.4	+7.4	Boonton	80	13	Layton	14	7	0.82	−2.38	2 stations	1.19	Northfield	0.42
New Mexico	40.9	−1.3	Grahams Ranch	88	1	2 stations	−36	[1] 24	1.26	+0.53	Dulce	8.44	Clayton	0.04
New York	45.8	+8.0	Geneva	79	[1] 9	Indian Lake	0	28	2.25	−0.77	High Market	4.60	Chazy	0.54
North Carolina	55.8	+5.9	Monroe	87	13	Altapass	13	7	0.84	−1.69	Rock House	3.84	3 stations	T.
North Dakota	30.3	+2.9	4 stations	78	[1] 2	3 stations	−10	[1] 21	0.55	−0.06	Grand Forks	1.77	Turtle Lake	0.00
Ohio	50.2	+8.7	Peebles	82	22	Mount Vernon	16	28	2.70	−0.10	Columbus (No. 2)	4.32	Youngstown	1.50
Oklahoma	54.1	+3.7	3 stations	89	[1] 3	Boise City	9	22	4.94	+2.92	Oklahoma City	9.63	Kenton	0.39
Oregon	36.0	−3.2	Brookings	80	3	Seneca	−30	29	3.53	−0.22	Willow Creek	16.61	Harper	0.18
Pennsylvania	49.2	+8.0	Hyndman	80	12	Mount Pocono	12	[1] 7	1.52	−1.34	Corry	4.42	Reading	0.36
South Carolina	58.8	+5.0	Darlington	87	21	Santuck	21	7	0.54	−1.75	Caesars Head	3.34	Aiken	0.00
South Dakota	34.7	+1.5	Bison	88	8	Spearfish	−12	22	0.98	+0.31	Canton	3.76	Ludlow	0.17
Tennessee	56.5	+8.1	Milan	85	13	Rugby	17	7	3.52	−0.10	2 stations	7.59	Embreeville	0.38
Texas	61.5	+4.3	Falfurrias	97	11	Romero	10	[1] 22	2.20	−0.12	Conroe	9.10	3 stations	0.00
Utah	32.3	−5.1	Springdale	84	5	Fort Duchesne	−19	[1] 24	1.54	+0.48	Silver Lake	4.77	Wendover	0.14
Virginia	53.8	+7.5	Kenbridge	87	20	Burkes Garden	14	7	0.64	−1.76	Pennington Gap	2.53	Rocky Mount	0.04
Washington	35.5	−4.1	Prosser (near)	76	1	Newport (a)	−10	27	5.00	−0.02	Big Four	22.99	Naches Heights	0.38
West Virginia	51.3	+8.6	Robertsburg	88	24	Moorefield	11	7	1.81	−1.08	New Martinsville	2.96	Moorefield	0.25
Wisconsin	41.2	+7.7	Fond du Lac	75	[1] 8	Solon Springs	0	26	4.17	+2.40	Darlington	6.13	Mellen	2.18
Wyoming	27.9	−3.2	2 stations	78	[1] 1	Riverside	−34	22	0.69	−0.06	Bechler River	3.01	Torrington	0.06
Alaska (October)	29.6	−1.1	do	62	[1] 4	Barrow	−14	28	4.34	+0.94	Yakutat	25.75	Barrow	0.03
Hawaii	72.3	+0.5	Pupukea	94	6	Kanalohuluhulu	46	[1] 15	6.72	−1.35	Honomu	33.61	3 stations	0.00
Porto Rico	76.6	−0.1	San German	96	7	Guineo Reservoir	40	15	10.89	+3.44	Paraiso	20.05	Mayaguez	2.29

[1] Other dates also.

TABLE 1.—*Climatological data for Weather Bureau stations, November, 1931*

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
New England							45.9	+6.4										76	1.10	−2.1										6.4		
Eastport	76	67	85	30.02	30.10	+0.09	42.8	+6.1	67	22	48	20	28	37	20	40	36	78	0.94	−2.4	8	6,763	sw.	29	nw.	13	5	5	20	7.5	T.	0.0
Greenville, Me	1,070	6		28.91	30.10		38.0		69	10	45	11	28	31	39				1.10		6	5,134	se.	25			14	7	19		2.0	0.0
Portland, Me	103	82	117	30.01	30.13	+.12	44.6	+6.6	74	10	52	22	28	38	36	39	34	73	1.24	−2.2	9	5,339	sw.	26	nw.	13	12	5	13	5.9	0.2	0.0
Concord	289	70	79	29.83	30.15	+.09	42.6	+4.9	73	10	52	10	28	33	42				1.05	−2.0	8	3,437	nw.	19	nw.	26	11	6	13	5.8	0.1	0.0
Burlington	403	11	48	29.67	30.13	+.08	42.8	+6.5	68	10	50	17	28	36	29				1.59	−1.1	12	8,764	s.	37	s.	21	2	7	21	8.2	1.0	0.0
Northfield	876	12	60	29.18	30.15	+.10	40.6	+7.8	71	10	50	10	28	31	37	37	33	79	1.20	−1.7	11	5,215	s.	26	sw.	25	0	13	17	7.9	0.2	0.0
Boston	125	106	165	30.02	30.16	+.11	49.4	+7.4	78	10	57	25	28	42	27	44	39	73	0.82	−2.5	6	5,139	sw.	24	nw.	6	9	9	12	5.6	T.	0.0
Nantucket	12	14	90	30.16	30.17	+.12	49.3	+4.9	66	24	55	34	7	44	17	46	42	78	1.68	−1.5	10	9,371	sw.	36	sw.	30	9	8	13	6.1	0.0	0.0
Block Island	26	11	46	30.14	30.17	+.11	49.2	+4.6	65	21	54	30	28	45	16	46	42	78	0.92	−2.7	7	11,134	sw.	38	nw.	6	11	7	12	5.7	0.6	0.0
Providence	160	215	251	30.00	30.17	+.10	48.0	+7.6	72	23	56	22	8	40	26	43	39	74	0.83	−2.2	11	6,597	nw.	34	nw.	6	11	8	11	5.3	0.3	0.0
Hartford	159	122		30.00	30.18	+.10	47.7	+8.2	76	10	56	21	28	40	30				0.95	−2.6	7		sw.				9	7	14	6.0	1.1	0.0
New Haven	106	74	153	30.07	30.19	+.12	48.4	+6.4	73	22	56	23	28	41	27	44	39	76	0.85	−2.5	8	4,932	n.	26	sw.	3	9	9	12	5.9	1.8	0.0
Middle Atlantic States							52.7	+7.7										76	0.69	−1.9										5.8		
Albany	97	107	115	30.06	30.17	+.09	47.2	+7.9	72	10	54	24	28	40	28	42	38	73	1.18	−1.6	8	4,975	s.	22	se.	18	8	5	17	6.4	1.6	0.0
Binghamton	871	10	84	29.22	30.16	+.07	48.2	+9.5	74	23	56	19	28	40	32				1.21	−1.2	13	4,099	sw.	24	sw.	21	3	4	23	8.4	2.2	0.0
New York	314	414	454	29.85	30.19	+.10	51.5	+7.3	72	13	58	30	7	45	23	46	41	73	0.61	−2.4	5	9,233	nw.	45	nw.	13	8	9	13	6.4	1.2	0.0
Bellefonte	1,050	5	36	29.05	30.17		46.8		74	12	58	23	7	36	42	41	38	81	0.90		7		sw.				5	6	19	7.4	3.0	0.0
Harrisburg	374	94	104	29.79	30.20	+.09	51.2	+8.4	74	18	59	30	7	44	32	45	41	74	0.73	−1.5	6	3,761	w.	27	nw.	5	3	14	13	6.8	2.2	0.0
Philadelphia	114	123	367	30.09	30.22	+.12	54.0	+8.3	74	21	60	34	27	47	23	48	42	72	1.00	−1.7	7	7,570	sw.	34	nw.	5	8	11	11	5.8	1.2	0.0
Reading	325	81	103	29.85	30.21		51.2	+8.7	73	21	58	29	7	44	24	47	44	81	0.36	−2.4	4	3,454	w.	22	nw.	6	7	10	13	6.4	1.5	0.0
Scranton	805	72	103	29.33	30.21	+.12	49.0	+8.5	72	23	57	24	7	41	32	44	40	76	0.62	−2.2	9	4,107	sw.	26	nw.	6	6	16	8	5.9	2.0	0.0
Atlantic City	52	37	172	30.15	30.21	+.11	52.9	+7.3	72	22	59	29	7	47	29	49	45	80	0.61	−2.2	7	9,066	w.	36	nw.	6	11	8	11	4.9	T.	0.0
Cape May	17	13	49				53.2	+5.8	74	22	60	32	7	46	25	49	46	82	0.53	−2.7	4		nw.				7	12	11		8.0	0.0
Sandy Hook	22	10	55	30.17	30.19		51.4		71	23	57	33	7	46	18	47	44	81	0.77	−2.5	7	8,447	sw.	37	n.	6	8	6	16	6.3	T.	0.0
Trenton	190	159	183	30.00	30.20		51.1	+6.7	75	21	59	28	7	43	27	46	42	77	0.94	−1.8	9	5,858	sw.	29	nw.	5	9	10	11	5.7	1.6	0.0
Baltimore	123	100	215	30.07	30.20	+.09	54.7	+8.4	76	21	62	34	7	47	24	48	43	72	1.13	−1.4	6	5,335	sw.	32	nw.	5	11	10	9	5.5	T.	0.0
Washington	112	62	85	30.09	30.21	+.09	54.0	+8.8	77	18	63	30	7	45	29	47	43	74	1.01	−1.4	5	3,189	s.	24	nw.	25	7	11	12	6.0	T.	0.0
Cape Henry	18	8	54	30.20	30.22		57.6	+5.5	80	19	65	36	7	51	25	52	49	79	0.21	−2.2	2	6,466	sw.	39	n.	6	12	10	8	4.6	0.0	0.0
Lynchburg	681	153	188	29.48	30.24	+.11	54.9	+7.7	82	16	66	26	7	44	39	48	43	73	0.45	−1.9	6	2,643	w.	22	n.	6	15	7	8	4.7	0.0	0.0
Norfolk	91	170	205	30.14	30.24	+.13	59.0	+7.6	78	21	67	39	7	51	29	51	48	77	0.29	−1.9	3	6,598	s.	24	nw.	6	15	7	8	4.1	0.0	0.0
Richmond	144	11	52	30.08	30.23	+.11	55.9	+7.6	79	12	67	30	7	45	36	48	44	77	0.24	−2.0	3	3,927	sw.	20	sw.	30	15	6	9	4.5	0.0	0.0
Wytheville	2,304	49	55	27.82	30.23	+.10	50.5	+7.5	74	16	61	19	7	40	37	44	39	74	0.50	−1.6	5	4,186	w.	27	nw.	5	13	8	9	4.9	0.0	0.0
South Atlantic States							60.7	+6.5										75	0.50	−1.9										4.1		
Asheville	2,253	89	104	27.87	30.26	+.12	53.4	+8.3	75	15	65	22	7	42	39	46	42	74	0.43	−1.8	4	4,451	se.	26	s.	20	12	6	12	5.1	0.0	0.0
Charlotte	779	55	62	29.39	30.24	+.11	58.8	+8.2	81	13	69	34	7	49	32	51	47	74	0.42	−2.2	5	2,529	s.	14	sw.	30	13	10	7	4.4	0.0	0.0
Greensboro	886	5	56	29.28	20.25		54.2		78	13	67	24	7	41	42	45	42	79	0.37		6	3,958	sw.	19	n.	6	14	7	9	4.6	0.0	0.0
Hatteras	11	5	50		30.20	+.11	61.4	+5.1	78	19	68	45	3	55	20	58	56	90	1.17	−2.3	2	6,159	ne.	30	n.	6	15	10	5	4.0	0.0	0.0
Raleigh	376	103	146	29.83	30.24	+.11	58.4	+7.4	80	13	68	34	7	48	30	49	42	65	0.06	−2.2	2	4,468	sw.	19	nw.	6	15	10	5	4.1	0.0	0.0
Wilmington	78	81	91	30.16	30.25	+.13	61.4	+5.4	82	13	72	37	7	51	35	53	49	75	0.15	−1.8	3	3,461	n.	18	sw.	30	16	7	7	3.7	0.0	0.0
Charleston	48	11	92	30.17	30.22	+.10	63.0	+4.9	79	13	71	42	1	55	26	56	52	78	0.53	−1.6	4	5,339	n.	26	ne.	26	17	8	5	3.3	0.0	0.0
Columbia, S. C	351	41	57	29.85	30.24	+.12	60.6	+6.6	83	13	72	33	8	49	37	51	43	63	0.52	−1.5	3	3,357	ne.	21	sw.	30	17	5	8	3.8	0.0	0.0
Due West	711	10	55	29.48	30.26		58.6		80	13	70	35	8	48	38				0.54		6	4,324	sw.	23	ne.	26	15	5	10	4.6	0.0	0.0
Greenville, S. C	1,039	139	146	29.12	30.23		59.0	+9.4	80	13	67	36	1	50	29	51	44	67	1.02	−2.2	7	4,410	ne.	23	ne.	26	12	9	9	4.5	0.0	0.0
Augusta	182	62	77	30.01	30.21	+.08	60.9	+6.4	84	14	74	32	8	48	43	51	47	74	0.19	−2.2	2	2,155	nw.	18	se.	20	17	6	7	3.7	0.0	0.0
Savannah	65	150	194	30.13	30.20	+.08	64.4	+5.9	81	14	74	40	7	55	27	56	52	76	0.04	−2.1	2	6,348	ne.	26	se.	20	16	7	7	3.6	0.0	0.0
Jacksonville	43	209	245	30.13	30.18	+.08	66.4	+4.2	81	30	74	39	1	58	24	60	57	81	0.97	−1.0	8	6,813	n.	27	e.	20	15	11	4	3.5	0.0	0.0
Florida Peninsula							72.7	+1.7										77	0.93	−1.3										4.7		
Key West	22	10	64	30.02	30.04	+.02	74.8	+0.5	82	30	79	67	1	71	10	69	67	81	0.68	−1.5	6	7,782	ne.	23	ne.	8	17	8	5	3.9	0.0	0.0
Miami	25	124	168	30.04	30.07	+.01	73.4	+1.6	80	30	78	53	1	69	16	67	64	74	2.08	−0.8	11	9,632	ne.	31	ne.	7	4	16	10	6.0	0.0	0.0
Tampa	35	79	197	30.09	30.13	+.05	69.8	+2.9	86	30	80	48	1	60	26	61	58	77	0.04	−1.7	1	8,705	ne.	28	e.	22	12	17	1	3.6	0.0	0.0
Titusville	44	5		30.09	30.14		71.1		89	30	79	50	1	63	25				0.58		6		nw.				7	19	4	5.2	0.0	0.0
East Gulf States							62.9	+6.8										75	1.62	−1.6										4.1		
Atlanta	1,173	190	198	28.97	30.22	+.09	59.8	+7.7	77	14	68	35	1	52	23	52	45	67	0.57	−2.5	3	5,239	e.	22	e.	26	14	5	11	4.6	0.0	0.0
Macon	370	78	87	29.82	30.22	+.09	60.0	+5.8	80	14	73	32	8	47	40	51	45	71	0.21	−2.3	3	3,197	n.	17	s.	17	15	7	8	3.9	0.0	0.0
Thomasville	273	49	103	29.89	30.18	+.06	64.9	+6.4	83	16	77	37	1	53	33	55	50	71	0.01	−2.7	1	4,099	ne.	17	se.	22	17	5	8	3.5	0.0	0.0
Apalachicola	36	11	51	30.13	30.17		65.6		81	5	73	42	1	58	26	60	58	84	0.04	−3.0	1	5,101	e.	22	e.	22	19	9	2	2.7	0.0	0.0
Pensacola	56	149	185	30.11	30.17	+.06	65.6	+5.4	80	5	72	42	1	59	22	60	56	77	0.55	−3.2	4	7,953	e.	29	s.	20	16	7	7	3.8	0.0	0.0
Anniston	741	9	57				58.9	+7.0	80	13	71	28	7	47	39				2.89	−0.4	5	3,059	se.	20	se.	21	12	8	10		0.0	0.0
Birmingham	700	11	48	29.43	30.20	+.08	62.3	+8.4	80	4	72	36	1	52	29	53	47	68	2.78	−0.5	5	4,089	se.	29	se.	20	17	5	8	4.1	0.0	0.0
Mobile	57	125	161	30.10	30.16	+.05	64.9	+6.3	79	19	74	39	1	56	29	59	57	82	0.80	−2.8	4	5,200	n.	26	nw.	20	15	5	10	4.2	0.0	0.0
Montgomery	223	100	112	29.95	30.20	+.08	62.6	+6.8	80	4	74	38	7	52	35	53	47	67	1.89	−1.3	4	3,252	e.	17	s.	17	15	8	7	3.8	0.0	0.0
Corinth	469	6					59.0		81	11	70	28	7	48	41				5.03		10		se.				6	17	7		0.0	0.0
Meridian	375	87	95	29.76	30.16	+.04	61.6	+7.4	81	4	73	32	7	50	38	54	50	77	2.67	−0.6	7	2,507	se.	23	w.	17	11	6	13	5.3	0.0	0.0
Vicksburg	247	65	73	29.88	30.17	+.05	62.9	+6.3	82	13	73	39	1	53	27	55	50	74	4.21	+0.5	8	4,242	se.	28	w.	20	12	8	10	5.0	0.0	0.0
New Orleans	53	76	84	30.08	30.13	+.03	68.6	+7.0	82	14	76	50	2	61	21	62	60	82	2.87	−0.3	8	3,819	se.	24	nw.	20	14	6	10	4.7	0.0	0.0
West Gulf States							64.2	+6.5										77	3.00	+0.1										5.9		
Shreveport	249	204	220	29.84	30.11	.00	62.0	+6.0	84	4	71	41	1	54	28	56	52	76	5.01	+1.4	11	6,692	s.	32	s.	19	10	8	12	5.9	0.0	0.0
Bentonville	1,303	11	44	28.69	30.07	−.04	55.4	+8.7	78	3	64	27	25	47	31				3.54		11	3,870	s.	20	se.	23	13	7	10		0.0	0.0
Fort Smith	457	79	94	29.59	30.08	−.03	58.3	+7.3	81	3	66	35	1	50	30	52	49	76	3.12	+0.2	11	4,972	e.	24	sw.	20	9	4	17	6.3	0.0	0.0
Little Rock	357	136	153	29.75	30.13	+.01	58.8	+6.7	79	11	66	38	1	51	30	52	48	74	8.30	+4.1	10	5,328	s.	28	w.	17	7	8	15	6.5	0.0	0.0
Austin	605	136	148	29.41	30.04		65.0	+6.5	85	6	75	42	30	55	38	57	52	72	1.09	−1.2	11	5,396	se.	28	n.	24	7	7	16	6.8	0.0	0.0
Brownsville	57	83	100	29.96	30.02		71.8	+4.6	89	17	80	51	25	64	30	64	61	77	0.88	−1.1	7	6,931	se.	33	n.	20	7	17	6	5.4	0.0	0.0
Corpus Christi	20	11	78	30.02	30.04	−.03	70.3	+6.0	83	19	77	49	30	64	25	64	61	76	1.70	−0.3	9	7,232	se.	34	nw.	20	6	14	10	5.7	0.0	0.0
Dallas	512	220	227	29.52	30.07		61.5		81	4	69	38	30	54	30				2.38	−0.2	12	7,923	se.	48	sw.	17	9	5	16	5.9	0.0	0.0
Fort Worth	670	106	114	29.33	30.05	−.05	62.0	+6.5	81	7	70	39	25	54	28	55	51	73	2.78	+0.2	11	5,785	se.	28	w.	17	9	6	15	6.0	0.0	0.0
Galveston	54	106	114	30.04	30.10	+.01	69.2	+5.9	82	5	74	51	25	64	23	64	62	81	3.74	+0.4	13	7,168	se.	30	nw.	20	11	10	9	5.0	0.0	0.0
Houston	138	292	314	29.93	30.08		67.6	+6.6	83	5	75	47	25	60	24				5.25	+1.4	12	8,927	se.	31	se.	22	9	11	10	5.6	0.0	0.0
Palestine	510	64	72	29.56	30.10	−.01	63.3	+6.1	82	4	72	42	1	55	28	57	54	83	3.29	−0.1	13	4,989	s.	22	se.	16	11	3	16	5.9	0.0	0.0
Port Arthur	34	58	66	30.05	30.09		67.8		83	5	75	48	25	61	24	62	60	85	3.13	0.0	14	4,390	e.	25	s.	20	6	13	11	6.0	0.0	0.0
San Antonio	693	242	301	29.30	30.02	−.06	66.6	+6.3	84	7	75	42	30	58	31	59	55	73	0.72	−1.2	7	8,736	e.	34	e.	16	6	11	13	6.2	0.0	0.0
Taylor	571	38	51	29.49	30.09	+.01	64.4	+6.7	84	13	74	40	30	54	38				0.64	−1.8	9	5,681	se.	26	se.	22	10	4	16	6.0	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, November, 1931*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	*° F.*	*° F.*	*°F.*		*°F.*	*° F.*		*°F.*	*° F.*	*° F.*	*° F.*	%	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
Ohio Valley and Tennessee							**54.2**	**+9.0**										**75**	**3.21**	**+0.1**										**5.9**		
Chattanooga	762	190	215	29.38	30.20	+0.06	57.8	+7.4	78	13	68	34	7	48	33	50	45	69	2.60	−0.8	9	3,637	se.	29	se.	20	13	8	9	4.5	0.0	0.0
Knoxville	995	102	111	29.15	30.22	+.09	55.6	+7.7	77	22	66	32	7	45	34	49	44	73	1.93	−1.1	8	2,922	sw.	26	s.	17	14	8	8	4.2	0.0	0.0
Memphis	399	76	97	29.72	30.15	+.03	58.8	+7.1	80	13	66	37	25	51	25	52	47	72	6.31	+2.1	9	4,419	s.	20	w.	17	12	6	12	5.3	T.	0.0
Nashville	546	168	191	29.61	30.20	+.08	57.8	+8.8	79	13	68	32	7	48	33	51	46	72	3.75	+0.2	10	5,373	s.	46	se.	20	14	5	11	4.9	0.0	0.0
Lexington	989	193	230	29.14	30.22	+.10	54.8	+10.0	76	22	62	28	26	47	29				2.50	−0.8	12	8,416	sw.	38	s.	20	9	8	13	5.9	T.	0.0
Louisville	525	188	234	29.60	30.18	+.06	55.4	+8.7	77	16	63	30	26	48	29	49	45	73	3.38	−0.2	11	6,636	s.	39	sw.	20	8	6	16	6.2	0.0	0.0
Evansville	431	76	116	29.68	30.16	+.04	55.6	+9.0	78	16	63	32	25	48	28	50	46	76	4.65	+0.9	12	6,052	s.	28	sw.	12	10	8	12	5.4	0.0	0.0
Indianapolis	822	194	230	29.24	30.14	+.04	51.7	+9.4	75	14	59	26	26	45	29	46	42	75	3.38	0.0	14	7,455	s.	31	sw.	17	9	7	14	6.4	2.9	0.0
Royal Center	736	11	55	29.31	30.12	------	48.8	------	73	16	57	20	26	40	34	----	----	----	2.94	+0.3	12	6,781	s.	32	sw.	20	6	9	15	6.7	1.7	0.0
Terre Haute	575	96	129	29.51	30.13	------	52.5	------	77	14	60	27	26	45	33	47	43	77	4.27	+1.0	13	6,203	s.	29	se.	20	9	6	15	6.2	5.5	0.0
Cincinnati	627	11	51	29.50	30.18	+.06	53.7	+11.2	76	16	61	26	26	46	30	47	43	75	3.01	+0.2	16	4,525	sw.	26	se.	20	7	9	14	6.3	2.0	0.0
Columbus	822	216	230	29.29	30.17	+.06	51.4	+9.5	74	22	59	25	26	44	27	46	42	76	3.64	+0.9	17	7,149	s.	31	w.	5	6	10	14	6.5	3.1	0.0
Dayton	899	137	173	29.20	30.17	------	52.0	+10.0	74	14	59	25	26	45	29	46	43	77	3.41	+0.6	16	5,655	sw.	30	s.	20	6	15	9	6.5	5.3	0.0
Elkins	1,947	59	67	28.16	30.25	+.13	49.8	+9.5	73	19	61	19	7	39	38	44	41	80	1.87	−0.9	11	3,406	w.	22	s.	20	6	10	14	6.7	T.	0.0
Parkersburg	637	77	82	29.55	30.22	+.10	53.2	+9.4	78	20	62	24	26	44	29	46	42	74	1.97	−0.6	15	3,250	se.	24	nw.	5	7	7	16	6.7	T.	0.0
Pittsburgh	842	353	410	29.27	30.19	+.09	51.6	+8.4	75	20	59	26	26	44	29	46	41	74	1.80	−0.5	13	6,509	w.	36	w.	5	5	11	14	6.5	2.5	0.0
																		75	**2.34**	**−0.4**										**7.5**		
Lower Lake Region							**48.4**	**+9.1**																								
Buffalo	767	247	280	29.26	30.10	+.05	47.9	+8.5	69	20	54	28	26	42	22	44	41	78	1.71	−1.3	14	12,818	sw.	56	w.	3	2	7	21	7.7	0.9	0.0
Canton	448	10	61	29.60	30.09	------	42.4	+8.5	71	17	50	18	27	34	32	----	----	----	2.12	−1.0	14	6,749	sw.	35	w.	25	1	10	19	7.8	0.4	0.0
Ithaca	836	74	100	29.23	30.15	------	48.7	+10.1	74	10	57	14	28	40	29	43	38	74	1.07	−1.3	13	6,940	s.	32	s.	21	2	8	20	7.8	2.6	0.0
Oswego	335	71	85	29.74	30.12	+.07	48.2	+9.3	73	23	55	20	28	41	33	43	38	74	1.92	−1.5	14	7,512	s.	26	w.	25	0	8	22	8.2	1.0	0.0
Rochester	523	86	102	29.55	30.13	+.08	49.1	+10.4	74	23	56	27	28	42	25	44	39	72	1.91	−0.6	14	5,666	sw.	29	sw.	3	2	9	19	7.8	0.9	0.0
Syracuse	596	65	79	29.49	30.14	+.08	48.6	+9.9	75	23	56	17	28	41	32	----	----	----	2.38	−0.4	15	4,700	s.	19	nw.	5	2	9	19	8.0	4.8	0.0
Erie	714	130	166	29.34	30.12	+.06	50.1	+8.7	74	23	56	25	28	44	28	45	42	75	2.79	−0.5	15	10,396	s.	42	sw.	5	3	13	14	7.1	1.1	0.0
Cleveland	762	267	337	29.30	30.13	+.06	51.2	+10.3	75	23	58	28	28	45	30	45	40	70	2.48	−0.2	14	9,911	s.	46	w.	5	3	8	19	7.9	3.1	0.0
Sandusky	629	5	67	29.45	30.15	+.07	49.5	+8.4	74	23	57	24	28	42	29	----	----	----	2.08	−0.3	13	6,366	sw.	27	w.	24	3	11	16	7.3	4.0	0.0
Toledo	628	208	243	29.44	30.14	+.07	48.9	+8.5	71	23	55	26	26	42	32	44	40	76	3.38	+1.0	11	9,334	sw.	36	w.	24	7	11	12	6.3	1.5	0.0
Fort Wayne	856	110	119	29.19	30.13	------	49.2	+8.6	71	23	56	24	26	42	31	44	41	80	2.64	−0.2	11	6,670	s.	32	se.	20	7	7	16	7.2	2.3	0.0
Detroit	730	218	258	29.32	30.12	+.06	47.8	+8.5	70	20	54	26	26	42	26	44	40	77	3.56	+1.1	12	7,197	sw.	33	sw.	12	5	8	17	7.3	0.7	0.0
																		79	**3.57**	**+1.1**										**7.2**		
Upper Lake Region							**44.1**	**+8.7**																								
Alpena	609	13	92	29.35	30.02	+.01	43.6	+9.2	68	9	51	22	26	36	30	40	36	78	3.33	+0.7	17	8,486	sw.	38	sw.	20	4	12	14	6.7	0.3	0.0
Escanaba	612	54	60	29.32	30.00	−.03	41.4	+8.3	60	10	48	16	26	35	28	38	34	78	3.02	+0.9	12	6,698	s.	34	sw.	20	8	8	14	6.1	T.	T.
Grand Haven	632	54	89	29.36	30.05	+.01	46.5	+8.0	67	16	53	26	25	40	32	44	40	78	3.85	+1.1	12	9,777	s.	38	sw.	24	5	4	21	7.6	T.	0.0
Grand Rapids	707	70	244	29.29	30.07	+.02	47.6	+9.2	73	9	55	27	25	40	33	43	39	76	3.27	+0.5	10	9,326	s.	44	sw.	24	3	8	19	7.6	T.	0.0
Houghton	668	64	99	29.20	29.94	−.08	40.7	+8.7	69	9	47	22	26	35	32	----	----	----	2.83	−0.2	17	6,950	e.	45	w.	24	5	4	21	8.0	2.9	1.0
Lansing	878	6	88	29.12	30.08	------	45.6	+8.1	71	9	53	22	26	38	34	42	40	87	3.35	+0.9	13	6,980	sw.	32	s.	20	5	3	22	7.7	T.	T.
Ludington	637	60	66	29.32	30.03	------	45.6	+8.2	65	20	51	26	25	40	33	43	40	80	3.20	+0.5	12	9,491	s.	41	sw.	20	6	9	15	6.7	T.	0.0
Marquette	734	77	111	29.14	29.96	−.06	42.2	+8.9	69	9	49	20	26	36	36	38	34	75	3.34	+0.4	16	7,560	w.	39	sw.	24	6	3	21	7.7	1.5	0.4
Port Huron	638	70	120	29.38	30.09	+.04	46.4	+8.9	69	23	53	24	26	39	25	42	39	79	2.25	−0.1	11	7,973	s.	30	nw.	5	2	12	16	7.0	0.4	0.0
Sault Sainte Marie	614	11	52	29.29	30.00	−.01	40.7	+8.7	66	9	47	20	26	35	32	38	35	82	4.71	+2.0	20	6,942	se.	42	nw.	3	3	8	19	7.7	5.3	1.5
Chicago	673	7	131	29.35	30.08	+.01	50.0	+9.9	73	9	56	24	25	44	37	45	41	74	4.63	+2.3	11	7,331	sw.	32	sw.	24	6	9	15	6.6	0.2	0.0
Green Bay	617	109	141	29.34	30.01	−.03	43.2	+9.2	67	9	50	17	26	36	41	39	36	78	3.61	+1.4	10	7,667	s.	42	s.	20	6	8	16	7.1	0.3	0.0
Milwaukee	681	125	221	29.30	30.04	−.01	47.1	+9.8	72	9	54	22	26	40	38	43	39	76	4.65	+2.9	9	9,399	w.	43	s.	20	6	11	13	6.4	T.	0.0
Duluth	1,133	5	47	28.70	29.95	−.09	36.2	+6.2	65	8	44	7	26	28	32	32	29	80	3.89	+2.4	15	8,104	w.	39	sw.	24	4	6	20	7.4	4.0	0.5
																		78	**0.62**	**−0.1**										**5.7**		
North Dakota							**30.8**	**+3.9**																								
Moorhead	940	50	58	28.94	29.98	−.09	33.0	+5.9	69	8	42	1	29	24	34	29	26	83	1.57	+0.7	7	5,563	s.	28	nw.	24	7	8	15	6.4	11.1	6.2
Bismarck	1,674	8	57	28.18	30.02	−.05	31.1	+2.6	74	2	40	3	28	22	39	26	22	77	0.25	−0.3	4	5,115	nw.	29	nw.	21	14	7	9	4.6	4.2	2.2
Devils Lake	1,478	11	44	28.37	29.99	−.07	29.9	+5.4	68	8	38	2	25	22	31	26	23	83	0.48	−0.2	6	5,971	nw.	28	nw.	24	7	11	12	6.3	5.1	3.4
Ellendale	1,457	10	56	28.41	30.01	------	30.8	------	72	7	41	−2	25	20	42	----	----	----	0.73	0.0	8	8,199	nw.	41	nw.	24	9	8	13	5.9	6.5	6.1
Grand Forks	833	12	67	----	----	----	31.3	------	69	8	40	−4	25	23	33	27	----	----	1.77	------	4	------	se.	44	nw.	24	13	3	14	----	10.9	10.7
Williston	1,878	41	48	27.98	30.03	−.03	29.0	+1.8	68	6	40	−2	27	18	37	24	18	71	0.05	−0.5	3	4,644	sw.	30	w.	6	14	5	11	5.1	0.7	0.0
																		78	**49.7**	**+3.0**										**6.6**		
Upper Mississippi Valley							**47.6**	**+9.2**																								
Minneapolis	918	102	208	28.96	29.96	------	40.3	+7.9	68	16	48	12	29	33	28	----	----	----	3.29	+2.0	15	6,891	w.	34	w.	24	7	8	15	6.6	0.7	T.
St. Paul	837	114	149	29.06	29.99	−.07	40.3	+7.8	68	16	48	11	29	33	31	----	----	----	2.94	+1.6	16	5,630	sw.	30	w.	24	6	9	15	6.5	1.7	T.
La Crosse	714	11	48	29.23	30.02	−.05	43.2	+8.0	69	16	52	16	26	34	41	39	36	82	4.78	+3.2	13	3,594	s.	31	sw.	20	5	10	15	6.9	0.3	0.0
Madison	974	70	78	28.98	30.04	−.02	44.8	+9.6	70	16	52	19	25	38	39	40	37	79	5.48	+3.7	9	6,399	w.	30	sw.	20	7	9	14	6.7	T.	0.0
Wausau	1,247	4	62	28.64	30.00	------	40.0	------	68	8	48	14	26	32	37	----	----	----	4.22	+2.4	9	4,560	w.	24	sw.	24	5	4	21	8.0	T.	T.
Charles City	1,015	10	51	28.94	30.04	−.04	41.4	+8.4	75	8	50	14	25	32	35	38	36	84	8.11	+6.6	10	4,734	se.	27	sw.	20	5	6	15	6.4	T.	0.0
Davenport	606	118	143	29.40	30.07	−.01	48.8	+9.8	76	16	56	20	25	41	37	43	39	76	4.99	+3.2	12	7,473	sw.	37	sw.	20	6	7	17	7.0	0.5	0.0
Des Moines	861	5	99	29.12	30.04	−.04	45.0	+6.6	78	8	54	18	25	36	37	41	38	81	7.10	+5.7	13	6,115	s.	33	nw.	9	5	5	20	7.5	2.2	T.
Dubuque	700	81	96	29.29	30.05	−.02	45.8	+8.8	73	16	54	17	25	38	40	41	38	79	4.86	+3.2	11	3,935	s.	22	nw.	17	5	9	16	6.8	T.	0.0
Keokuk	614	64	78	29.41	30.10	+.01	51.0	+9.9	78	8	59	23	25	43	35	45	41	74	3.85	+1.9	13	5,015	s.	27	s.	20	11	3	16	6.2	1.0	0.0
Cairo	358	87	93	29.76	30.14	+.02	56.6	+9.3	78	16	64	32	25	49	28	50	45	73	5.35	+1.7	10	5,385	s.	25	sw.	17	9	5	16	6.3	0.0	0.0
Peoria	609	11	45	29.43	30.10	+.01	50.2	+12.7	78	8	59	23	25	42	36	44	41	79	5.55	+3.2	13	4,513	s.	25	sw.	20	11	4	15	6.0	0.7	0.0
Springfield, Ill.	636	5	91	29.41	30.10	.00	52.0	+9.8	78	8	60	26	25	44	34	46	42	76	5.07	+2.6	11	8,545	s.	39	s.	20	9	5	16	6.3	2.8	0.0
Hannibal	534	74	109	29.51	30.09	.00	52.6	+10.5	80	8	60	26	25	45	31	----	----	----	4.29	+2.2	12	6,093	sw.	31	sw.	20	8	6	16	6.1	3.0	0.0
St. Louis	568	265	303	29.49	30.10	.00	54.8	+9.7	82	8	63	30	25	47	35	48	43	72	4.65	+1.8	13	8,472	sw.	44	sw.	14	11	7	12	5.6	0.3	0.0
																		74	**4.58**	**+3.2**										**5.8**		
Missouri Valley							**44.3**	**+5.3**																								
Columbia, Mo.	784	6	84	29.24	30.08	−.01	52.8	+9.5	80	8	61	26	25	44	31	----	----	----	3.94	+1.7	12	5,224	s.	31	sw.	20	9	6	15	6.1	2.9	0.0
Kansas City	963	161	181	29.02	30.07	−.02	50.6	+6.9	79	8	58	28	24	43	30	46	42	75	9.52	+7.7	14	5,376	s.	39	sw.	23	10	3	17	6.4	2.0	0.0
St. Joseph	967	11	49	29.00	30.05	------	49.0	------	80	8	58	23	25	40	32	44	41	80	8.35	+6.7	15	5,221	se.	30	nw.	9	10	5	15	5.9	0.5	0.0
Springfield, Mo.	1,324	98	104	28.66	30.08	−.02	54.3	+8.6	79	3	62	26	25	47	28	48	43	73	4.08	+1.3	14	7,081	s.	30	s.	23	12	8	10	4.9	0.6	0.0
Iola	964	11	50	28.99	30.05	−.04	51.4	+7.3	80	8	61	26	25	42	35	----	----	----	8.13	+6.3	15	3,982	s.	20	sw.	20	9	4	17	6.6	2.1	0.0
Topeka	987	92	107	----	----	----	49.1	+6.3	80	8	58	25	24	40	35	----	----	----	7.07	+5.6	13	5,544	sw.	29	sw.	9	10	2	18	6.1	1.8	0.0
Lincoln	1,189	11	81	28.75	30.04	−.04	43.8	+4.7	80	8	53	20	29	35	39	39	35	77	5.60	+4.5	10	5,845	s.	26	nw.	11	8	7	15	6.3	4.2	T.
Omaha	1,105	115	122	28.84	30.04	−.04	44.6	+6.1	80	8	53	17	29	36	31	39	35	74	5.07	+4.0	10	4,303	s.	23	n.	3	10	7	13	5.8	4.7	T.
Valentine	2,598	47	54	27.28	30.06	−.02	35.4	+0.8	81	8	49	0	29	22	46	27	21	67	0.40	−0.2	4	5,164	w.	27	nw.	21	11	8	11	5.3	5.1	2.3
Sioux City	1,135	94	164	28.78	30.02	−.06	40.6	+5.4	78	8	49	8	29	32	42	36	32	78	4.00	+3.0	14	6,920	nw.	34	s.	16	6	10	14	6.3	3.0	0.3
Huron	1,306	59	74	28.60	30.03	−.05	34.4	+2.9	79	8	45	−1	29	24	43	30	25	74	0.56	0.0	7	5,533	se.	31	nw.	20	12	8	10	5.0	3.4	1.5
Pierre	1,572	70	75	28.31	30.03	−.05	35.4	+1.8	81	8	47	8	28	24	44	29	22	66	0.54	+0.1	5	4,869	nw.	34	nw.	20	12	9	9	4.9	7.6	3.5
Yankton	1,233	49	57	28.64	30.05	−.03	39.1	+3.8	80	8	49	6	29	29	42	----	----	----	2.23	+1.4	10	4,244	nw.	26	s.	16	9		12	6.1	5.6	4.5

TABLE 1.—*Climatological data for Weather Bureau stations, November, 1931*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	° *F.*	° *F.*	°*F.*		°*F.*	° *F.*		°*F.*	° *F.*	° *F.*	° *F.*	%	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
Northern Slope							**30.3**	**−2.4**										**69**	**0.86**	**+0.2**										**6.0**		
Billings	3,140	5					32.2		77	2	44	−6	27	20	40				0.72		5		nw.				11	8	11		8.4	4.0
Havre	2,505	11	44	27.35	30.06	+0.03	26.4	−4.8	73	1	38	−20	22	15	45	22	17	71	0.57	0.0	7	6,366	sw.	36	w.	2	10	7	13	5.9	9.5	5.5
Helena	4,110	87	112	25.78	30.09	−.01	29.4	−3.8	70	7	38	−6	22	21	30	24	18	66	0.84	+0.1	9	4,144	sw.	26	sw.	18	6	13	11	6.2	16.1	7.1
Kalispell	2,973	48	56	26.96	30.11	+.04	27.2	−5.2	62	6	35	−9	22	19	32	26	23	85	2.57	+1.2	14	2,985	nw.	26	sw.	14	2	8	20	7.8	31.3	8.7
Miles City	2,371	48	55	27.47	30.09	+.02	31.8	+0.9	76	2	43	−2	27	21	43	26	20	72	0.54	0.0	7	3,661	s.	34	nw.	20	11	8	11	5.7	7.7	2.8
Rapid City	3,259	50	58	26.57	30.07	−.01	36.2	+0.3	77	7	48	6	21	25	38	28	20	61	0.44	0.0	4	4,700	w.	30	nw.	23	12	8	10	4.9	4.9	1.8
Cheyenne	6,088	84	101	23.95	30.06	−.01	32.8	−2.0	71	2	44	−6	22	21	35	25	16	56	0.40	−0.1	5	7,888	w.	44	w.	17	16	5	9	3.9	5.4	0.5
Lander	5,372	60	68	24.61	30.12	+.02	27.2	−3.1	70	2	40	−13	29	15	39	22	16	70	0.77	+0.2	4	2,617	sw.	30	s.	15	17	8	5	3.5	7.2	5.5
Sheridan	3,790	10	47	26.06	30.07		31.4		74	6	44	−3	27	19	45	25	19	68	0.67	0.0	9	2,464	nw.	28	sw.	16	11	11	8	5.3	5.1	1.8
Yellowstone Park	6,241	11	48		30.15	+.04	24.6	−4.7	62	5	34	−12	21	15	31			74	1.24	0.0	12	5,060	sw.	35	sw.	8	8	8	14		22.2	9.8
North Platte	2,821	11	51	27.05	30.05	−.03	37.4	+0.8	80	7	50	9	25	24	47	29	21	63	0.59	+0.1	4	3,974	w.	20	nw.	20	11	8	11	5.1	6.2	2.6
Middle Slope							**44.6**	**+1.8**										**68**	**3.46**	**+2.5**										**5.0**		
Denver	5,292	106	113	24.69	30.04	−.02	37.6	−2.2	78	2	49	0	22	27	35	28	17	51	0.59	0.0	8	4,400	s.	29	sw.	17	18	6	6	3.5	15.6	3.4
Pueblo	4,685	80	86	25.27	30.04	−.01	37.3	−2.1	78	2	52	2	25	23	50	29	18	52	0.42	+0.1	6	3,429	nw.	29	nw.	20	16	7	7	4.1	5.4	1.1
Concordia	1,392	50	58	28.56	30.07	−.01	45.0	+3.6	81	8	54	20	30	36	37	40	36	80	2.61	+1.6	11	4,476	sw.	26	sw.	9	13	5	12	5.2	4.9	0.7
Dodge City	2,509	88	100	27.42	30.06	−.01	44.4	+1.8	82	8	55	17	22	34	46	37	32	74	1.32	+0.6	8	8,096	nw.	37	nw.	9	15	5	10	4.7	2.9	T.
Wichita	1,358	139	158	28.58	30.03	−.05	49.4	+4.6	79	8	58	27	24	41	28	44	39	74	6.21	+4.8	13	7,256	s.	44	s.	9	9	6	15	6.2	3.0	0.0
Oklahoma City	1,214	10	47	28.75	30.05	−.03	53.8	+5.0	82	3	63	30	30	45	31	48	44	76	9.63	+7.8	10	5,678	s.	24	w.	16	8	7	15	6.3	T.	0.0
Southern Slope							**54.5**	**+2.7**										**67**	**1.85**	**+0.8**										**5.1**		
Abilene	1,738	10	52	28.22	30.03	−.04	57.8	+4.3	79	7	67	33	30	49	32	51	47	74	3.49	+2.1	10	6,059	s.	30	s.	16	12	3	15	5.8	0.0	0.0
Amarillo	3,676	10	49	26.27	30.03	−.02	47.0	+1.5	84	3	58	16	22	36	38	39	34	70	2.89	+2.0	10	5,202	s.	21	s.	8	12	9	9	4.8	8.2	0.0
Del Rio	944	64	71	28.99	29.98	−.07	64.4	+4.4	84	23	74	38	20	55	36	56	50	66	0.64	−0.6	7	6,038	se.	29	nw.	16	12	5	13	5.7	0.0	0.0
Roswell	3,566	75	85	26.37	30.01	−.02	48.7	+0.6	80	3	63	24	27	34	46	39	30	57	0.38	−0.5	5	4,319	s.	30	nw.	19	13	12	5	4.2	0.7	0.0
Southern Plateau							**47.3**	**−1.9**										**60**	**1.08**	**+0.6**										**3.7**		
El Paso	3,778	152	175	26.17	29.97	−.03	54.0	+1.3	81	3	66	32	30	42	37	42	31	47	0.64	+0.1	5	6,402	w.	42	w.	28	17	6	7	3.6	2.0	2.0
Albuquerque	4,972	51	66	25.04	29.99		42.2		74	3	55	5	24	30	40	34	27	61	1.19		7	3,291	ne.	31	se.	21	11	13	6	4.5	4.6	T.
Santa Fe	7,013	38	53	23.21	30.02	−.01	37.1	−1.8	67	2	47	2	24	27	30	29	23	64	1.16	+0.5	10	4,224	n.	32	se.	22	14	7	9	4.4	11.3	2.8
Flagstaff	6,907	10	59	23.28	29.96	−.06	32.4	−2.2	69	3	44	−5	29	21	42	27		80	2.57		15	4,564	sw.	26	sw.	15	6	14	10		14.0	3.0
Phoenix	1,108	10	107	28.80	29.96	−.02	57.2	−2.5	94	3	68	27	23	46	40	47	39	58	3.18	+2.5	8	2,744	e.	19	sw.	21	20	4	6	3.6	0.0	0.0
Yuma	141	9	54	29.83	29.98	.00	58.8	−3.6	93	4	71	31	23	46	38	48	38	51	0.14	−0.2	4	3,217	n.	22	n.	20	22	5	3	2.2	0.0	0.0
Independence	3,957	6	27	25.96	30.04	−.01	44.4	−2.8	78	3	58	11	23	31	38	33			0.29	0.0	1		nw.				20	3	7		T.	0.0
Middle Plateau							**34.9**	**−4.3**										**64**	**1.33**	**+0.6**										**4.4**		
Reno	4,532	74	81	25.47	30.07	−.04	38.6	−2.4	77	3	51	10	23	26	41	32	23	59	0.43	−0.2	6	3,567	sw.	30	sw.	17	14	8	8	4.1	3.4	0.0
Tonopah	6,090	12	20				35.4		69	1	43	2	22	28	22	28	20	60	0.66		5		se.									
Winnemucca	4,344	18	56	25.64	30.12	−.02	32.6	−5.8	75	4	47	0	23	18	49	27	20	66	0.80	+0.1	7	4,689	ne.	24	nw.	8	15	6	9	4.5	4.8	0.1
Modena	5,473	10	43	24.59	30.05	−.03	30.7	−5.7	73	3	44	−11	23	18	45	25	19	71	2.17	+1.6	9	5,134	w.	27	sw.	10	14	3	13	4.5	14.8	3.2
Salt Lake City	4,360	163	203	25.63	30.08	−.04	36.2	−4.9	74	6	44	9	24	28	29	30	22	58	1.95	+0.6	10	4,332	s.	33	s.	14	15	5	10	4.2	14.6	2.3
Grand Junction	4,602	60	68	25.38	30.02	−.06	36.6	−2.7	69	3	47	3	25	26	37	30	25	70	1.31	+0.7	11	2,855	nw.	20	s.	16	14	6	10	4.6	7.8	0.8
Northern Plateau							**35.3**	**−4.1**										**71**	**1.46**	**+0.1**										**6.5**		
Baker	3,471	48	53	26.46	30.13	−.03	31.0	−5.0	65	1	40	−2	30	22	32	27	21	68	1.53	+0.5	14	3,743	se.	22	w.	7	8	9	13	6.0	15.3	4.8
Boise	2,739	79	87	27.22	30.14	−.03	36.7	−4.3	72	6	46	8	22	27	34	31	25	68	1.38	+0.1	8	3,049	se.	22	se.	13	11	7	12	5.6	7.3	1.6
Lewiston	757	40	48	29.29	30.13	+.01	37.9	−3.5	67	1	44	15	22	31	26				1.19	−0.4	14	2,200	e.	18	sw.	8	2	8	20	8.0	1.2	T.
Pocatello	4,477	60	68	25.49	30.12	−.02	32.8	−3.9	71	2	42	−1	22	24	37	28	22	72	0.85	0.0	7	5,980	se.	31	sw.	18	7	13	10	5.4	10.6	3.0
Pasco	416	5	33				37.3		72	1	46	6	26	28	39			73	1.47		7	5,356	nw.				5	7	18		5.3	3.5
Spokane	1,929	101	110	28.01	30.11	+.01	33.3	−5.2	66	1	40	4	28	26	28	31	27	77	2.41	+0.3	13	3,438	s.	24	sw.	19	7	5	18	6.6	13.9	3.4
Walla Walla	991	57	65	29.02	30.11	−.02	38.8	−4.0	70	1	45	12	30	33	28	35	31	73	2.38	+0.4	10	2,805	s.	23	se.	9	3	11	16	7.6	4.3	3.4
Yakima	1,076	58	67	28.93	30.11		36.4	−2.5	65	6	46	7	28	27	30	32	25	66	0.48	−0.4	5	2,713	nw.	26	sw.	19	9	5	16	6.2	2.1	0.2
North Pacific Coast Region							**43.8**	**−2.4**										**81**	**5.17**	**−0.9**										**6.8**		
North Head	211	11	56	29.82	30.06	+.01	45.2	−3.0	66	4	50	33	22	40	18	43	39	81	7.04	−1.4	17	9,216	n.	56	s.	6	10	0	20	6.9	0.0	0.0
Port Angeles	29	8	53		30.06		41.8		55	1	48	27	21	36	18				3.62	−0.3	15	3,785	s.	27	w.	19	4	12	14		T.	0.0
Seattle	125	215	250	29.91	30.04	.00	43.2	−2.4	59	4	48	29	30	39	16	41	37	78	2.66	−2.4	15	5,836	s.	33	s.	19	8	5	17	6.5	0.0	0.0
Tacoma	194	172	201	29.84	30.06	+.02	42.4	−2.2	61	1	48	23	30	37	17				2.74	−3.5	14	5,724	s.	36	sw.	19	5	7	18	7.3	T.	0.0
Tatoosh Island	86	9	53	29.92	30.02	+.05	44.8	−1.1	59	4	48	35	16	42	10	43	41	87	11.28	−0.6	16	10,408	e.	55	s.	18	5	7	18	7.0	0.6	0.0
Medford	1,329	29	58	28.67	30.11		40.8		73	1	51	19	23	31	33	38	34	81	3.12	+0.6	11	1,920	nw.	29	nw.	7	10	6	14	5.9	0.8	0.0
Portland, Oreg.	153	68	106	29.92	30.09	−.01	44.0	−2.8	67	1	50	25	30	38	21	40	36	76	6.38	+0.3	14	4,125	se.	24	sw.	19	8	1	21	6.9	0.0	0.0
Roseburg	510	75	99	29.55	30.11	−.01	43.2	−2.7	70	1	50	22	23	37	24	41	38	83	4.51	−0.2	13	2,225	s.	18	s.	19	4	10	16	7.1	0.0	0.0
Middle Pacific Coast Region							**50.9**	**−2.9**										**66**	**2.74**	**0.0**										**3.7**		
Eureka	62	73	89	30.04	30.12	+.01	47.0	−4.1	67	3	54	30	22	40	21	45	43	86	5.75	+0.6	15	3,483	se.	28	n.	20	14	4	12	4.6	0.0	0.0
Red Bluff	330	5	58	29.70	30.06	−.05	51.6	−2.2	82	3	62	29	23	41	35	43	33	56	1.93	−1.0	7	4,389	nw.	29	s.	13	16	6	8	3.7	0.0	0.0
Redding	722	20	34				51.8		83	3	61	30	22	43	29			52	3.76		6	5,252	nw.				15	8	7		0.0	0.0
Sacramento	69	106	117	29.97	30.04	−.05	50.6	−3.0	83	6	60	28	23	41	33	45	39	68	1.30	−0.6	8	4,672	se.	24	n.	21	20	5	5	2.7	0.0	0.0
San Francisco	155	208	243	29.88	30.05	−.04	54.4	−1.9	80	6	61	39	23	48	25	48	42	70	2.93	+0.6	10	4,398	w.	34	n.	21	16	6	8	3.8	0.0	0.0
San Jose	141	12	110	29.92	30.07		51.0	−3.4	82	7	62	28	24	40	34				1.79	+0.3	7	3,452	nw.	23	se.	14	16	6	8	3.7	0.0	0.0
South Pacific Coast Region							**56.2**	**−2.0**										**63**	**1.89**	**+0.9**										**3.7**		
Fresno	327	89	98	29.69	30.05	−.01	52.8	−1.4	86	4	63	28	22	42	34	45	36	59	1.76	+0.8	5	3,023	nw.	24	nw.	8	17	7	6	3.3	T.	0.0
Los Angeles	338	159	191	29.65	30.02	.00	58.7	−2.2	87	4	67	40	24	50	32	49	41	59	1.95	+0.8	3	3,207	ne.	19	nw.	21	16	7	7	3.5	0.0	0.0
San Diego	87	62	70	29.91	30.00	−.02	57.2	−2.5	81	4	65	38	24	50	28	52	47	72	1.95	+1.2	7	3,572	e.	24	se.	15	13	8	9	4.4	0.0	0.0
West Indies																																
San Juan, P. R.	82	9	54	29.79	29.87		78.6	+0.2	89	9	83	68	18	74	14				15.64	+8.9	24	6,408	s.	35	e.	16	1	23	6	6.2	0.0	0.0
Panama Canal																																
Balboa Heights	118	6	97	29.73	[1] 29.81	−0.1	78.0	−1.1	88	17	83	70	9	73	16			[1] 88	12.60	+2.4	26	4,194	nw.	24	s.	1	0	5	25	8.4	0.0	0.0
Cristobal	36	6	97	29.79	[1] 29.82	−0.1	79.1	−0.2	88	6	84	72	8	75	12	75	74	[1] 85	30.31	+9.1	27	6,345	w.	37	w.	8	1	8	21	8.3	0.0	0.0
Alaska																																
Fairbanks	455	11	44	[2] 29.28	[2] 29.84		9.0		42	4	18	−29	19	0	44	11	8	88	0.38		10	1,252	n.	14	w.	12	6	7	17	6.9	6.7	6.7
Juneau	80	11	50	[2] 29.86	[2] 29.95		33.6		47	5	37	16	20	30	12	32	28	80	7.76		20	4,115	s.	27	e.	14	6	1	23	7.6	5.6	0.0
Hawaiian Islands																																
Honolulu	38	86	100	[2] 29.95	[2] 29.99		75.0	+0.5	81	7	79	63	29	71	14	69	66	75	1.02	−2.8	12	5,737	e.	24	e.	8	6	17	7	5.7	0.0	0.0

[1] Observations taken hourly.

[2] Pressure not reduced to mean of 24 hours.

TABLE 2.—*Data furnished by the Canadian Meteorological Service, November, 1931*

Stations	Altitude above mean sea level, Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Departure from normal	Mean max.+ mean min.÷2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	*Inches*	*Inches*	*Inches*	°F.	°F.	°F.	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*
Cape Race, N. F.	99				38.9		45.1	32.7	54	16	3.94		0.1
Sydney, C. B. I.	48												
Halifax, N. S.	88												
Yarmouth, N. S.	65												
Charlottetown, P. E. I.	38												
Chatham, N. B.	28												
Father Point, Que.	20				37.9	+8.9	44.1	31.8	64	16	1.89	−1.87	3.8
Quebec, Que.	296	29.72	30.05	+.03	31.0		38.9	23.1	60	6	2.95		13.6
Doucet, Que.	1,236				41.5	+9.7	47.7	35.4	67	22	2.68	−1.06	1.6
Montreal, Que.	187	29.83	30.04	+.01									
Ottawa, Ont.	236	29.80	30.07	+.05	41.1	+9.4	49.5	32.7	67	18	2.03	−0.51	1.5
Kingston, Ont.	285	29.79	30.11	+.07	44.4	+9.4	50.1	38.7	62	24	2.40	−0.84	T.
Toronto, Ont.	379	29.68	30.09	+.05	45.8	+10.2	51.8	39.8	66	28	2.44	−0.70	0.6
Cochrane, Ont.	930				32.6		39.2	26.1	63	12	4.49		13.0
White River, Ont.	1,244	28.57	29.91	−.07	32.7	+12.2	40.7	24.8	64	8	6.43	+4.58	5.3
London, Ont.	808				44.4		51.9	36.8	69	24	2.72		0.6
Southampton, Ont.	656	29.33	30.06	+.04	44.9	+9.9	51.5	38.3	70	24	4.67	+0.97	3.8
Parry Sound, Ont.	688	29.34	30.04	+.03	42.0	+9.9	48.0	36.0	63	20	3.88	−0.49	1.5
Port Arthur, Ont.	644	29.21	29.92	−.08	37.0	+13.0	43.2	30.8	54	16	3.47	+2.14	0.6
Winnipeg, Man.	760												
Minnedosa, Man.	1,690	28.10	29.97	−.07	24.6	+7.3	32.9	16.4	61	−2	0.11	−0.89	0.
Le Pas, Man.	860				20.3		28.8	11.9	48	−9	0.70		7.0
Qu'Appelle, Sask.	2,115	27.64	29.95	−.05	22.8	+4.0	32.0	13.6	59	−14	0.64	−0.25	6.4
Moose Jaw, Sask.	1,759				25.0		36.1	13.8	65	−11	0.34		3.4
Swift Current, Sask.	2,392	27.36	29.97	−.05	25.4	+2.2	35.2	15.7	72	−16	0.54	−0.15	5.0
Medicine Hat, Alb.	2,365												
Calgary, Alb.	3,540												
Banff, Alb.	4,521												
Prince Albert, Sask.	1,450	28.37	30.00	−.03	22.0	+6.6	30.6	13.4	57	−10	0.98	+0.15	9.8
Battleford, Sask.	1,592	28.21	30.02	.00	19.9	+3.6	29.9	10.0	62	−20	0.67	+0.09	6.7
Edmonton, Alb.	2,150												
Kamloops, B. C.	1,262												
Victoria, B. C.	230	29.78	30.04	+.05	42.5	−0.7	46.5	38.6	56	30	5.28	−1.69	0.0
Barkerville, B. C.	4,180												
Estevan Point, B. C.	20												
Prince Rupert, B. C.	170												
Hamilton, Ber.	151	30.04	30.20	+.15	69.2	+0.5	74.0	64.5	81	61	6.46	+2.08	0.0

LATE REPORTS, 1931, VARIOUS MONTHS

Cape Race, N. F. (June)	99				43.2		47.4	39.0	60	26	4.45		0.0
Cape Race, (October)					45.9		52.1	39.7	59	25	2.95		0.0
Father Point, Que. (May)	20	29.85	29.87	−0.06	46.0	+2.0	52.7	39.3	64	26	2.01	−0.57	0.0
Father Point, Que. (June)		29.90	29.92	+.05	54.3	+1.3	62.8	45.7	74	40	3.29	+0.31	0.0
Father Point, Que. (October)									84	29	2.07	+0.37	0.0
Winnipeg, Man. (October)	760	29.09	29.92	−.06					104	40	0.86	−1.23	0.0
Medicine Hat, Alb. (July)	2,365	27.46	29.90	.00	67.3	−0.5	81.8	52.8	31	14	0.15	−0.43	0.0
Medicine Hat, Alb. (October)		27.45	29.94	−.03	46.0	+1.2	60.7	31.3	55	7	0.15	−0.48	1.5
Calgary, Alb. (February)	3,428	26.30	30.06	+.07	32.5	+19.0	44.8	20.2	63	−10	2.60	+1.88	26.0
Calgary, Alb. (March)		26.41	30.23	+.28	26.2	0.0	36.9	15.6	91	40	1.60	−1.08	0.0
Calgary, Alb. (July)		26.34	29.95	+.05	61.7	+1.1	74.0	49.4	76	16	0.23	−0.25	T.
Calgary, Alb. (October)		26.22	29.90	−.05	43.7	+3.6	58.8	30.5	89	34	1.25	−2.09	0.0
Banff, Alb. (July)	4,521	25.41	29.92	+.02	58.3	+1.7	74.0	42.5	78	15	0.25	−0.22	0.0
Battleford, Sask. (April)	1,592	28.22	29.98	+.01	41.5	+4.3	56.4	26.7	71	16	1.00	+0.30	T.
Edmonton, Alb. (October)	2,150	27.56	29.85	−.08	42.5	+1.4	55.5	29.5	71	16	1.00	+0.30	2.0
Kamloops, B. C. (January)	1,262	28.66	29.98	+.02	34.6	+11.6	38.7	30.5	52	20	0.26	−0.56	3.6
Kamloops, B. C. (March)		28.72	30.03	+.11	41.6	+5.5	49.1	34.2	63	18	0.80	+0.23	T.
Kamloops, B. C. (May)		28.68	29.96	+.07	59.6	+0.5	70.6	48.6	85	39	0.60	−0.64	0.0
Kamloops, B. C. (July)		28.65	29.91	−.03	70.5	+2.0	83.9	57.1	100	47	0.45	−1.16	0.0
Estevan Point, B. C. (March)	20				42.9		49.4	36.4	53	29	11.29		0.0
Estevan Point, B. C. (May)					50.6		56.3	44.9	64	40	2.87		0.0
Estevan Point, B. C. (July)					56.6		63.4	49.8	70	44	0.91		0.0
Prince Rupert, B. C. (March)	170				40.5		46.4	34.7	55	22	6.80		T.
Prince Rupert, B. C. (May)					48.6		55.0	42.1	71	32	8.42		0.0
Prince Rupert, B. C. (July)					56.0		62.5	49.4	71	42	2.87		0.0
Prince Rupert, B. C. (October)					47.5		53.0	42.1	60	35	13.41		0.0

Chart I. Departure (°F.) of the Mean Temperature from the Normal, November, 1931

Chart I. Departure (°F.) of the Mean Temperature from the Normal, November, 1931

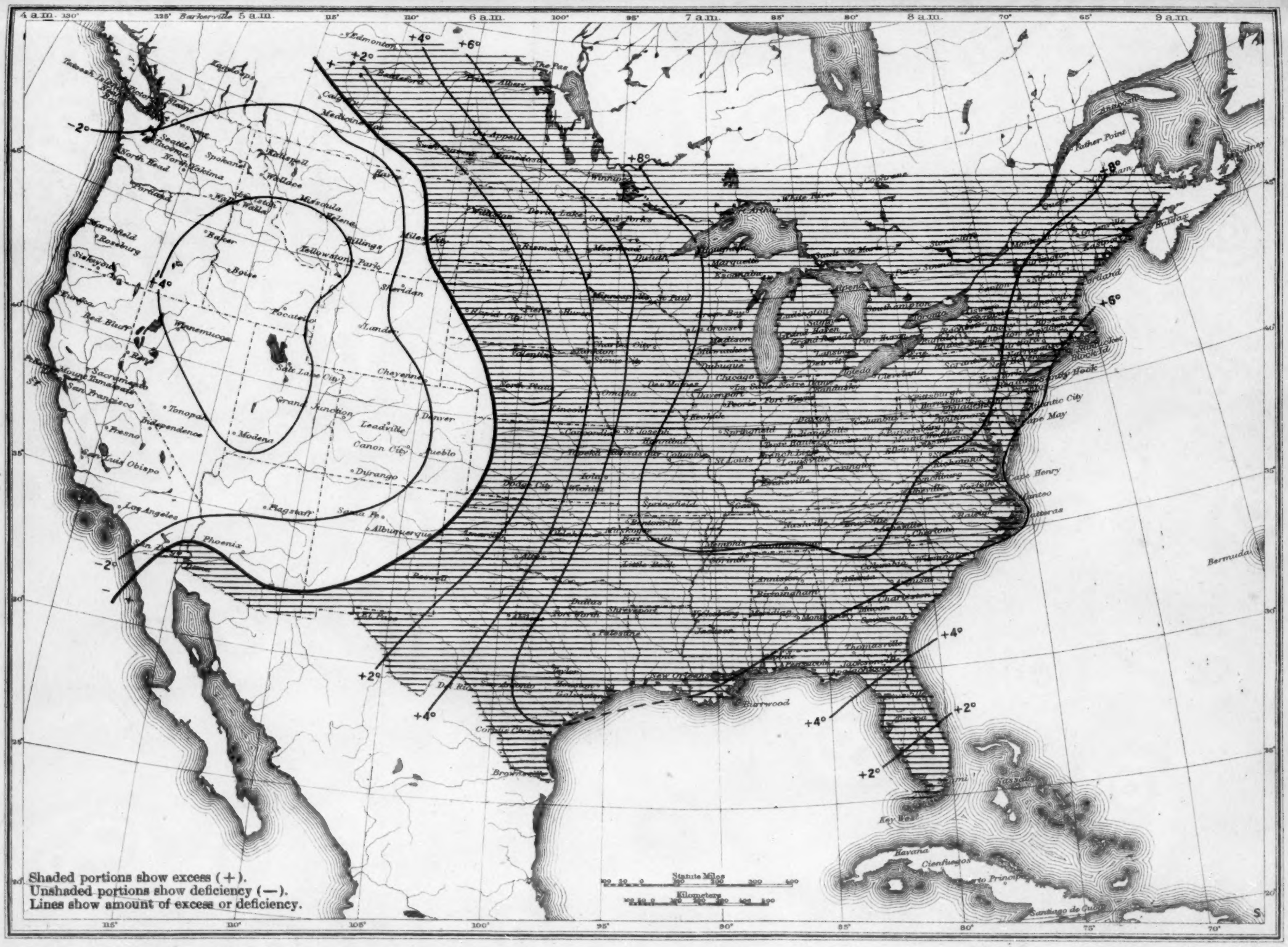
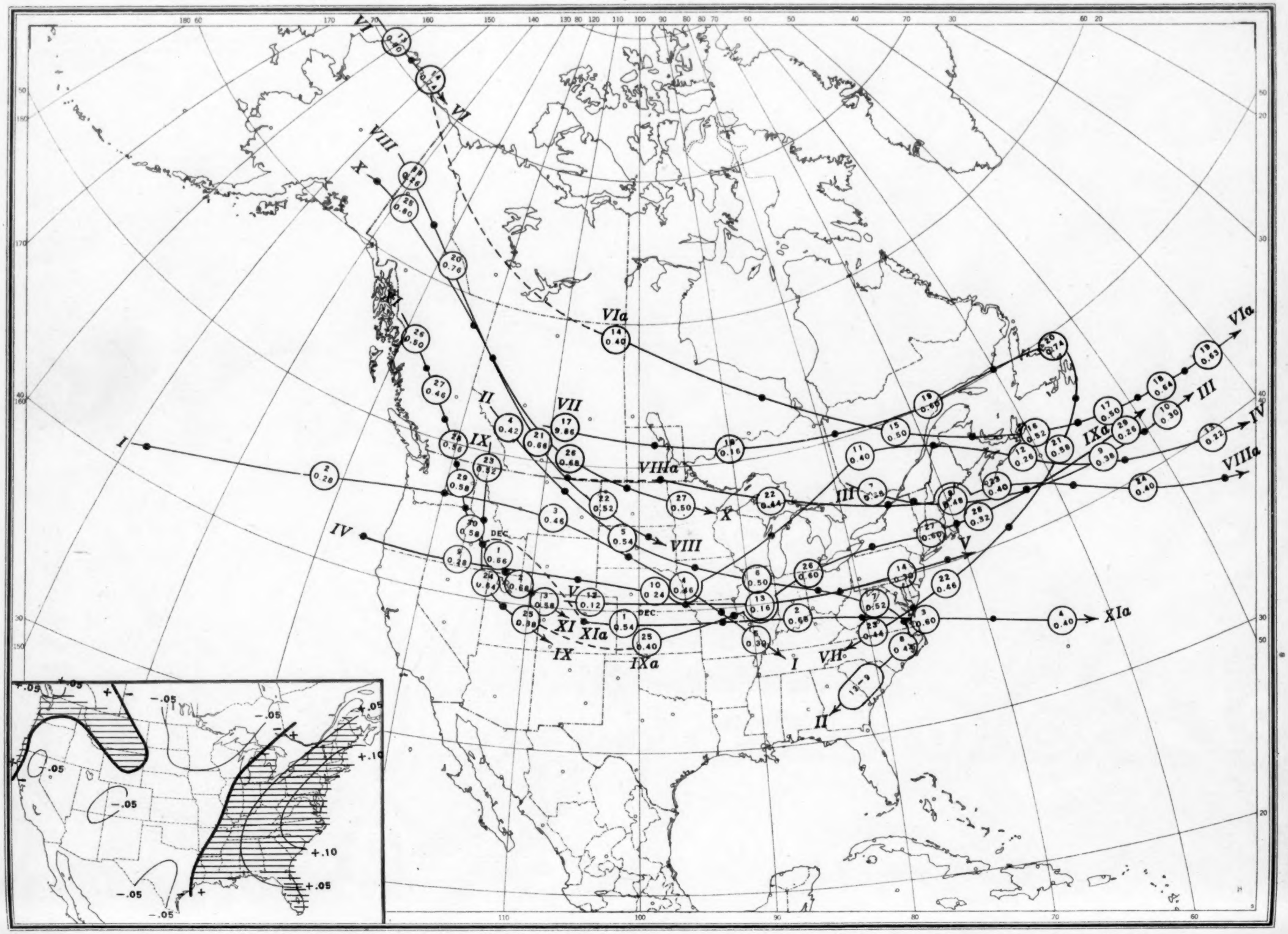


Chart II. Tracks of Centers of Anticyclones, November, 1931. (Inset) Departure of Monthly Mean Pressure from Normal

(Plotted by G. E. Dunn)



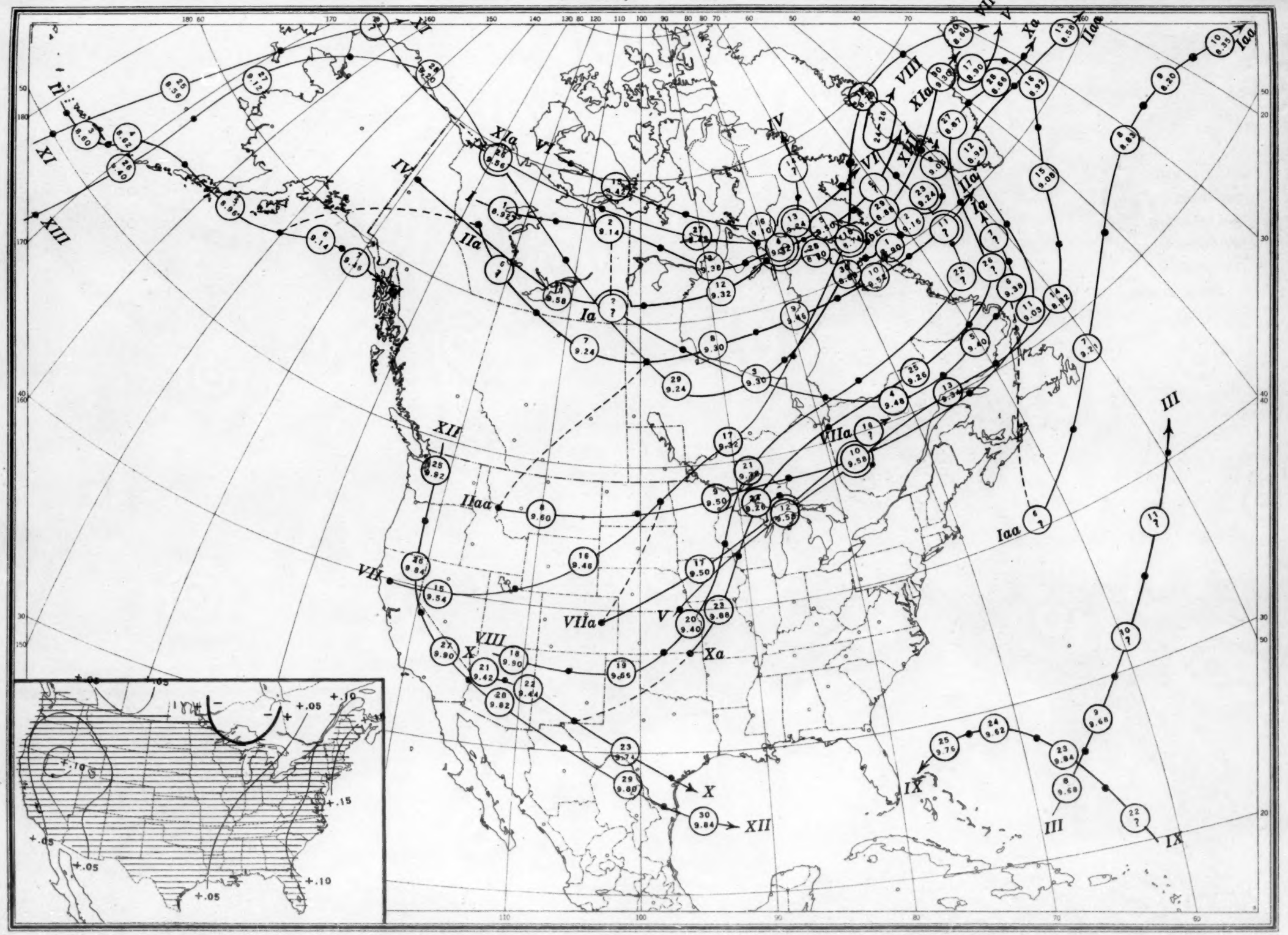
Circle indicates position of anticyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 8 p. m. (75th meridian time).

Chart III. Tracks of Centers of Cyclones, November, 1931. (Inset) Change in Mean Pressure from Preceding Month

(Plotted by G. E. Dunn)

Chart III. Tracks of Centers of Cyclones, November, 1931. (Inset) Change in Mean Pressure from Preceding Month

(Plotted by G. E. Dunn)



Circle indicates position of cyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of cyclone at 8 p. m. (75th meridian time).

Chart IV. Percentage of Clear Sky between Sunrise and Sunset, November, 1931

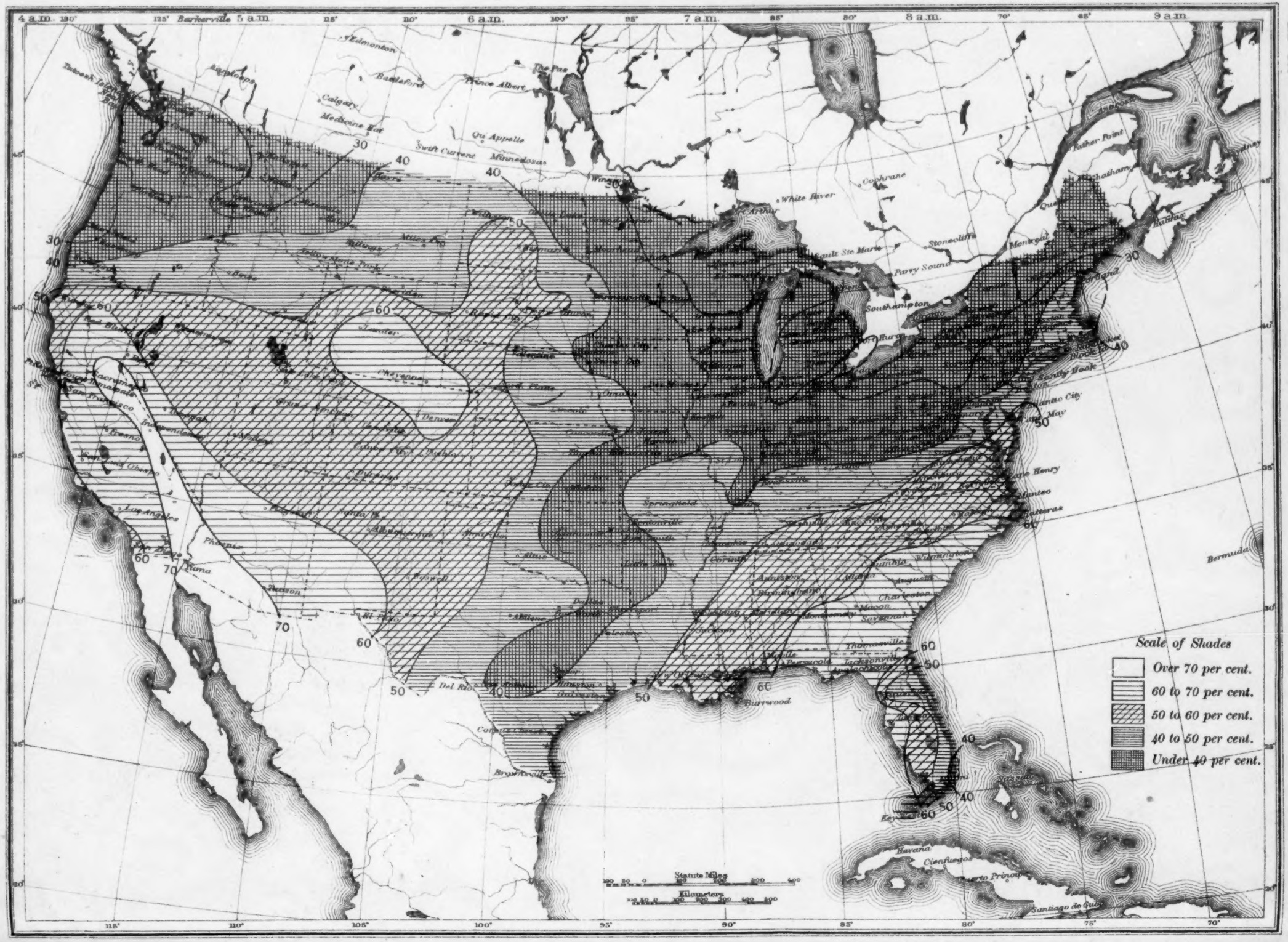


Chart V. Total Precipitation, Inches, November, 1931. (Inset) Departure of Precipitation from Normal

Chart V. Total Precipitation, Inches, November, 1931. (Inset) Departure of Precipitation from Normal

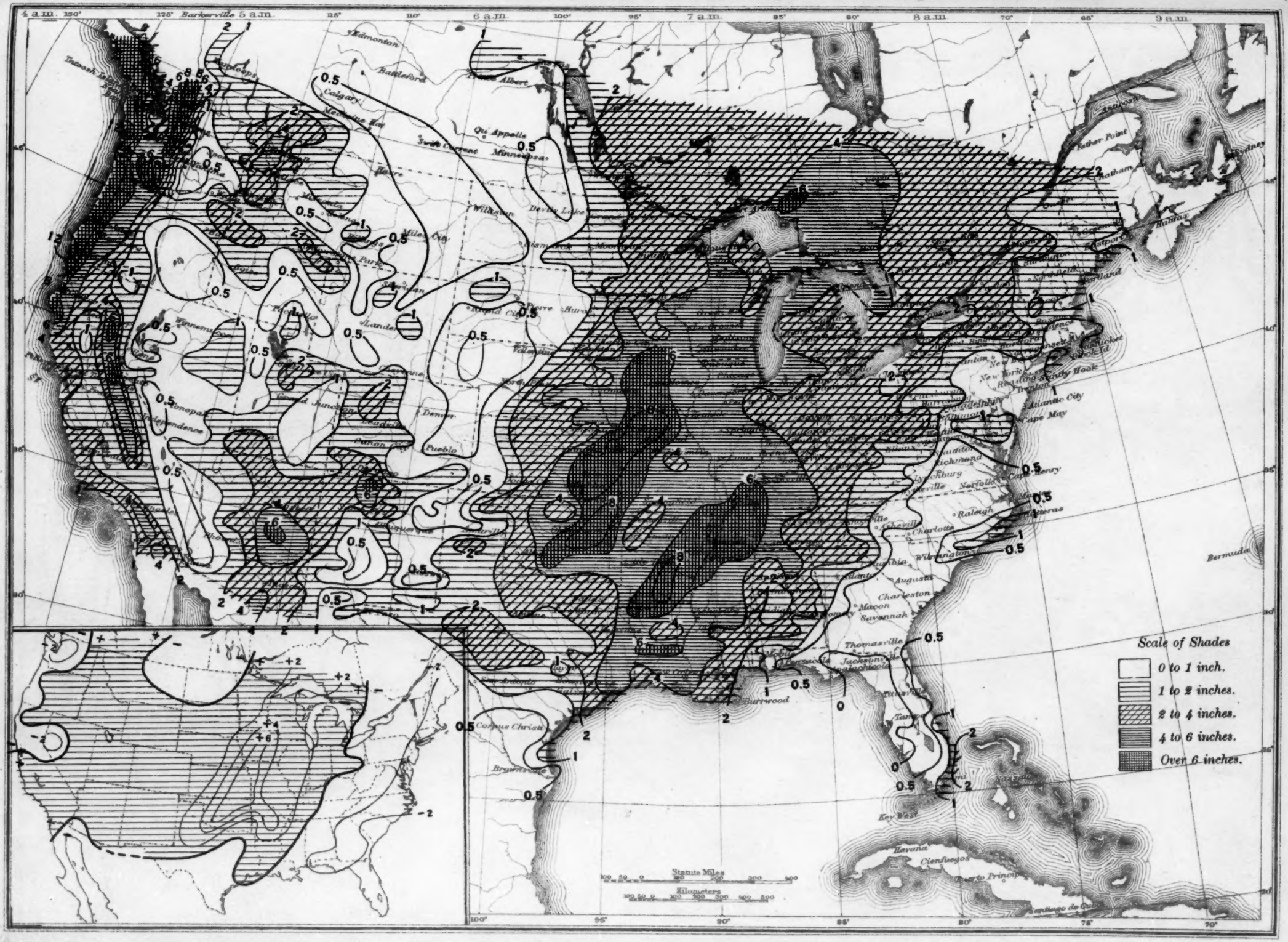


Chart VI. Isobars at Sea level and Isotherms at Surface; Prevailing Winds, November, 1931

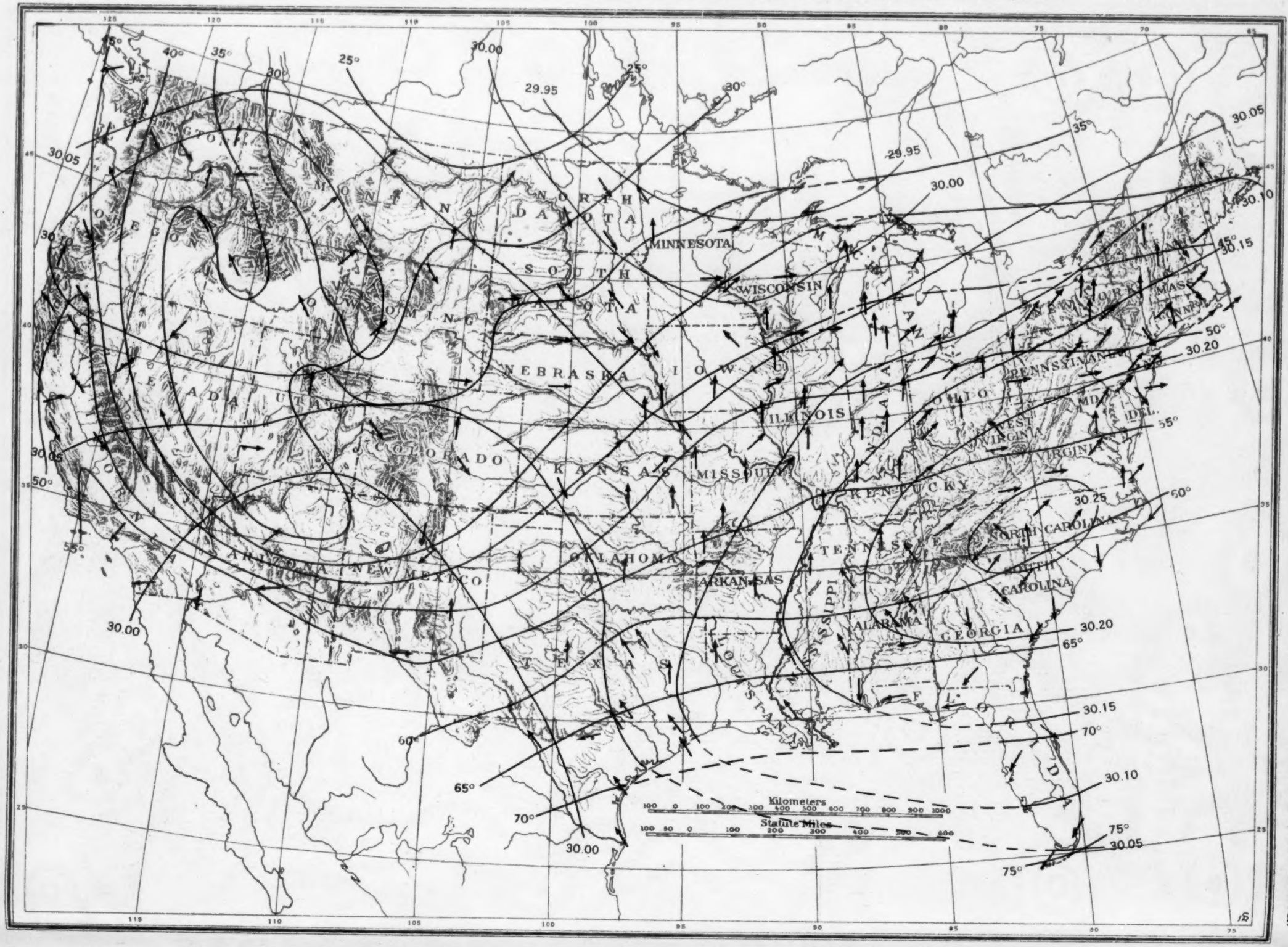


Chart VII. Total Snowfall, Inches, November, 1931. (Inset) Depth of Snow on Ground at end of Month

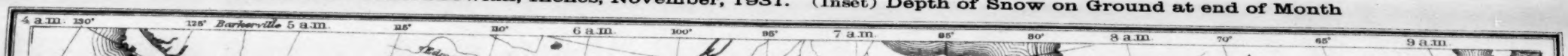


Chart VII. Total Snowfall, Inches, November, 1931. (Inset) Depth of Snow on Ground at end of Month

Chart VIII. Weather Map of North Atlantic Ocean, November 7, 1931
(Plotted from the Weather Bureau Northern Hemisphere Chart)

Chart VIII. Weather Map of North Atlantic Ocean, November 7, 1931

(Plotted from the Weather Bureau Northern Hemisphere Chart)

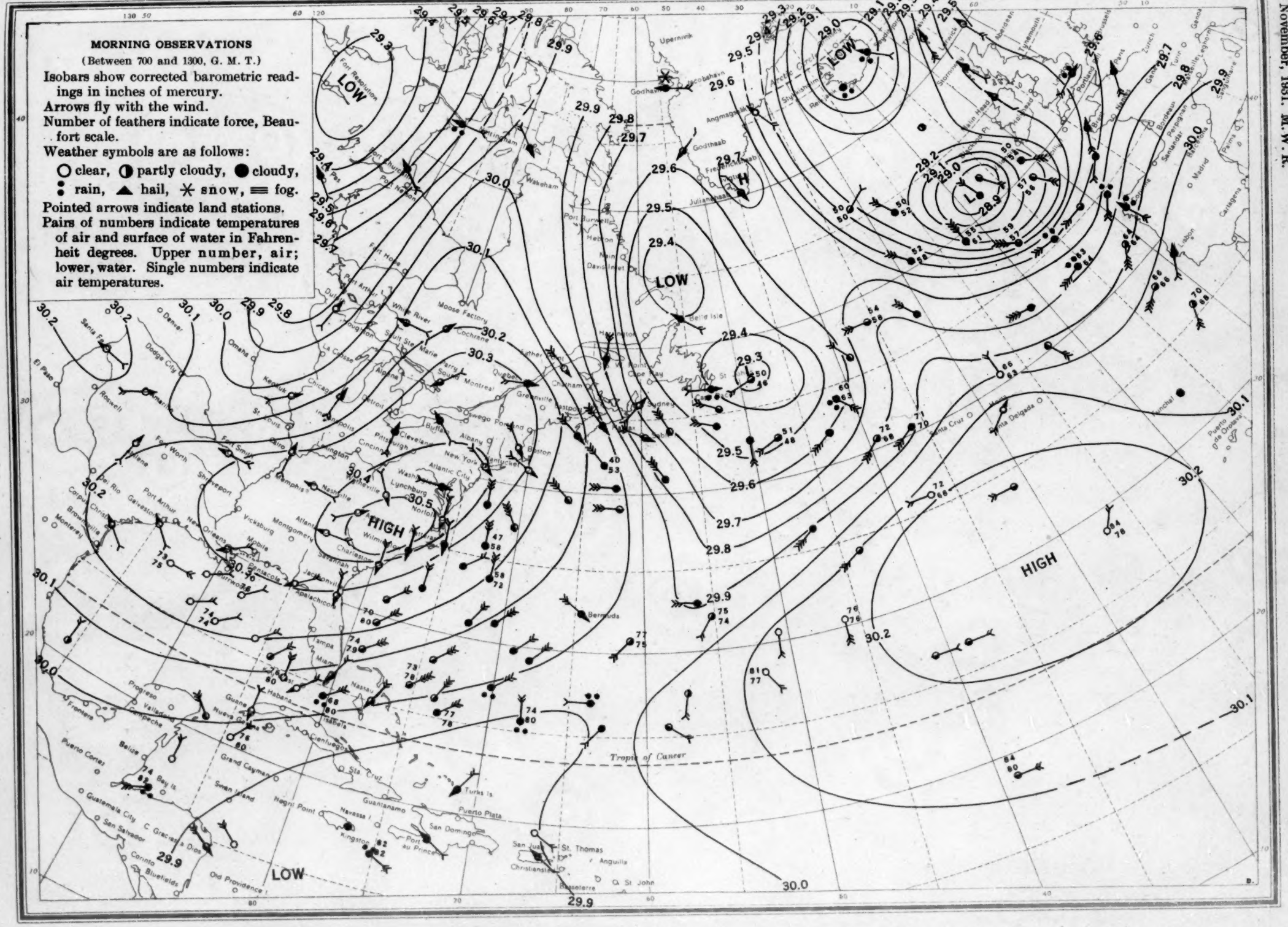

MORNING OBSERVATIONS
(Between 700 and 1300, G. M. T.)
Isobars show corrected barometric readings in inches of mercury.
Arrows fly with the wind.
Number of feathers indicate force, Beaufort scale.
Weather symbols are as follows:
clear, partly cloudy, cloudy, rain, hail, snow, fog.
Pointed arrows indicate land stations.
Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water. Single numbers indicate air temperatures.
LOW
HIGH
Tropic of Cancer

Chart IX. Weather Map of North Atlantic Ocean, November 8, 1931

(Plotted from the Weather Bureau Northern Hemisphere Chart)

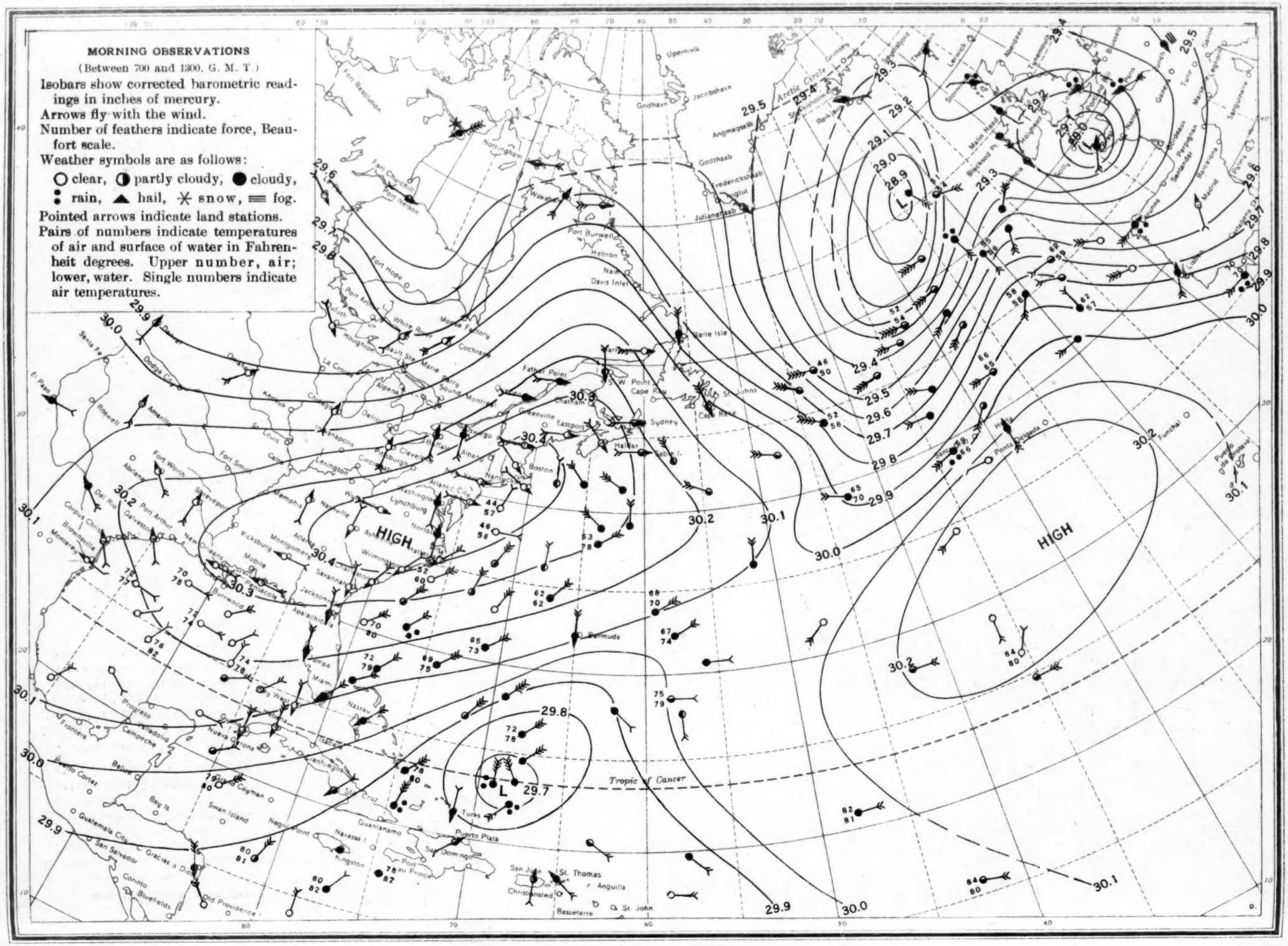
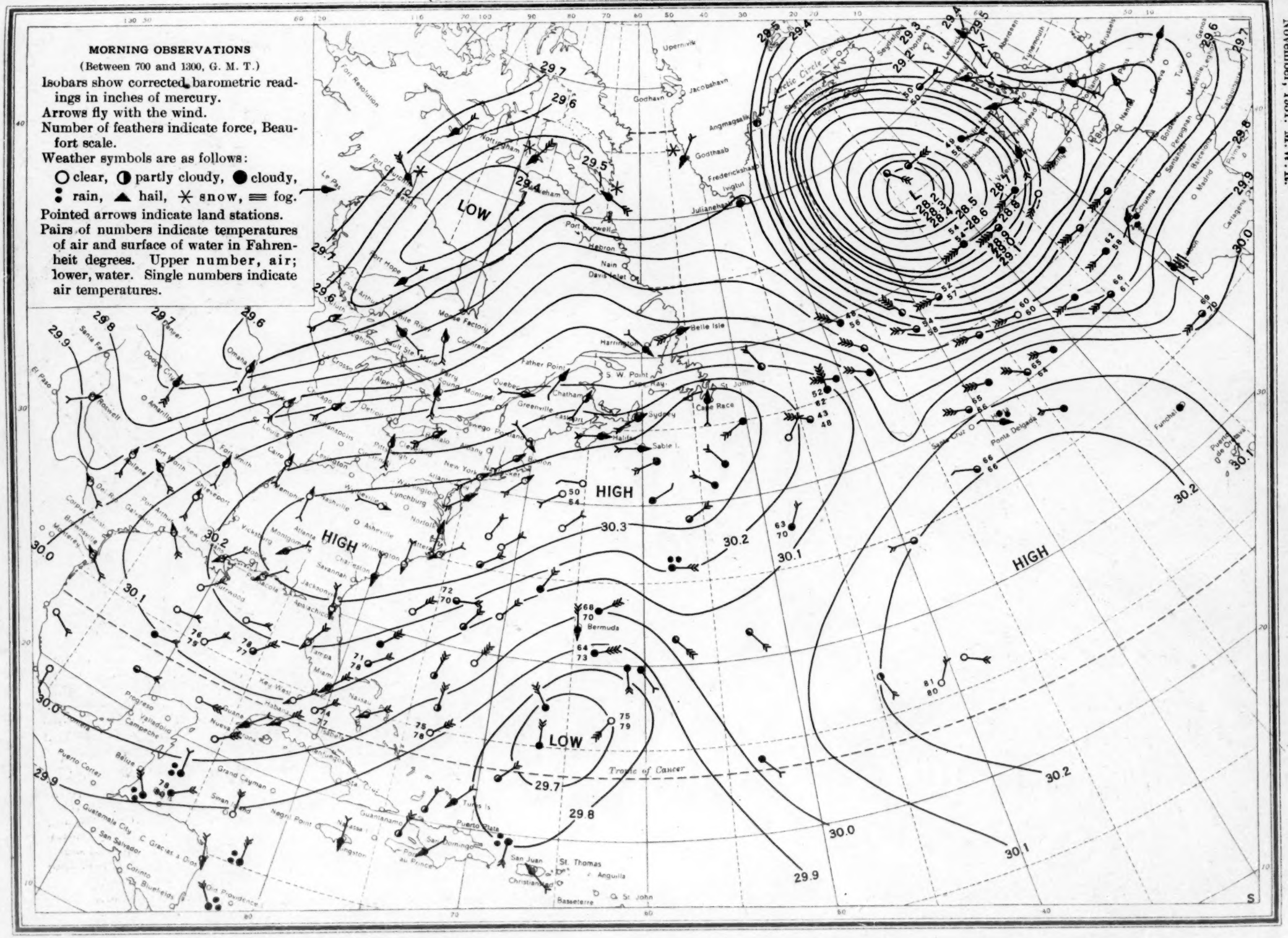


Chart X. Weather Map of North Atlantic Ocean, November 9, 1931

(Plotted from the Weather Bureau Northern Hemisphere Chart)

Chart X. Weather Map of North Atlantic Ocean, November 9, 1931

(Plotted from the Weather Bureau Northern Hemisphere Chart)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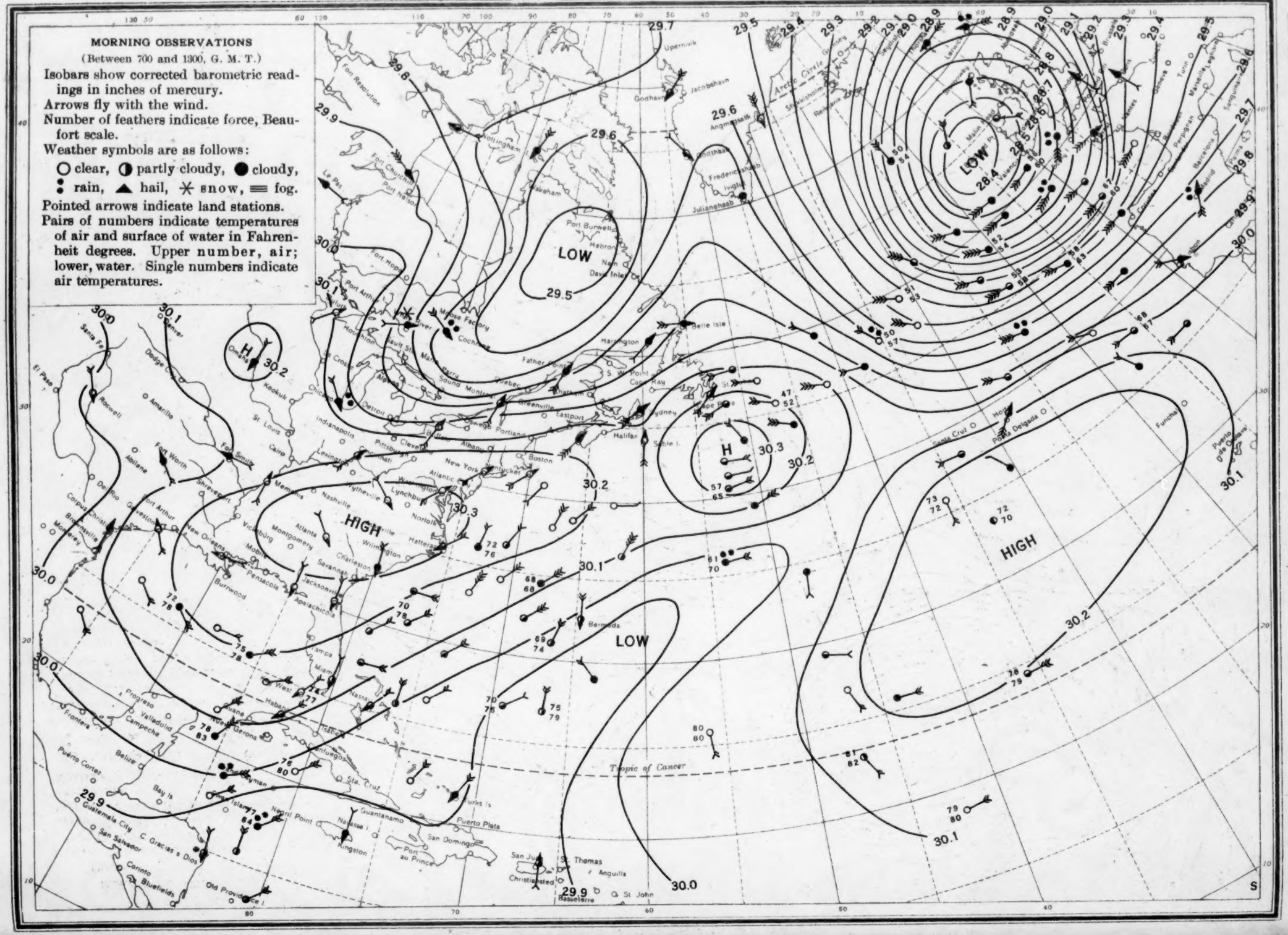
LOW
HIGH
HIGH
LOW
HIGH
Tropic of Cancer
Arctic Circle
Fort Resolution
Upernivik
Godhavn
Jakobshavn
Angmagssalik
Godthaab
Fredericksháab
Ivigtut
Julianehaab
Le Pas
Fort Churchill
Fort Nelson
Fort Graham
Port Burwell
Hebron
Nain
Davis Inlet
Fort Hope
Port Arthur
White River
Moose Factory
Cochrane
Belle Isle
Harrington
Father Point
S. W. Point
Cape Ray
St. Johns
Cape Race
Quebec
Montreal
Chatham
Greenville
Yarmouth
Sydney
Halifax
Sable I.
Oswego
Rochester
Buffalo
Toronto
Parry Sound
Alpena
Detroit
Port Huron
Grand Rapids
Milwaukee
Chicago
Duluth
Minneapolis
St. Paul
Omaha
Denver
Dodge City
Amarillo
Santa Fe
El Paso
Roswell
Fort Worth
Abilene
Shreveport
Fort Smith
Cairo
Memphis
Louisville
Cincinnati
Columbus
Pittsburgh
Lynchburg
Washington
Baltimore
Philadelphia
New York
Boston
Nantucket
Albany
Buffalo
Portland
Atlanta
Montgomery
Vicksburg
Nashville
Asheville
Wilmington
Norfolk
Charleston
Savannah
Jacksonville
Apalachicola
Pensacola
Tampa
Miami
Key West
Nassau
Havana
Progreso
Valladolid
Campeche
Belize
Puerto Cortez
Guatemala City
San Salvador
Corinto
Bluefields
Grand Cayman
Swan Island
Negril Point
Kingston
Guantanamo
Turks Is
Puerto Plata
Port au Prince
San Domingo
San Juan
Christiansted
St. Thomas
Anguilla
St. John
Basseterre
Bermuda
Funchal
Ponta Delgada
Santa Cruz
Puerto de la Cruz
Las Palmas
Madrid
Barcelona
Palma
Cartagena
Malaga
Gibraltar
Tangier
Casablanca
Lisbon
Oporto
Coruña
Santander
Bordeaux
Perpignan
Marseille
Toulon
Nice
Genoa
Turin
Florence
Rome
Naples
Palermo
Trapani
Malta
Pantelleria
Tripoli
Benghazi
Sfax
Algiers
Oran
Bizerta
Tunis
Aberdeen
Thurso
Stornoway
Lerwick
Valentia
Shannon
Galway
Roches Point
Queenstown
Scilly
Falmouth
Portland
Holyhead
Liverpool
Blackpool
Glasgow
Belfast
Donaghadee
Greenock
Prestwick
Aberdeen
Tynemouth
Scarborough
Hull
Yarmouth
Lowestoft
Harwich
Sheerness
Dover
Portsmouth
Weymouth
Plymouth
Falmouth
Scilly
Valentia
Shannon
Galway
Roches Point
Queenstown

Chart XI. Weather Map of North Atlantic Ocean, November 10, 1931

(Plotted from the Weather Bureau Northern Hemisphere Chart)


MORNING OBSERVATIONS
(Between 700 and 1300, G. M. T.)
Isobars show corrected barometric readings in inches of mercury.
Arrows fly with the wind.
Number of feathers indicate force, Beaufort scale.
Weather symbols are as follows:
clear, partly cloudy, cloudy,
rain, hail, snow, fog.
Pointed arrows indicate land stations.
Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water. Single numbers indicate air temperatures.
HIGH
LOW
Arctic Circle
Tropic of Cancer